JUN 1 1925
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Vol. 17, No. 2 May, 1925

PARASITOLOGY

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VOLUME XVII MAY, 1925 No. 2

THE PRESENT STATUS OF THE AMPHISTOME PROBLEM

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(*From the Molteno Institute for Research in Parasitology.*)

WHILE working on the amphistomes in the Congo Collection of the American Museum of Natural History, New York, it has been necessary to review the literature on this group of trematodes. In an earlier paper (1917), the writer described certain amphistomes from reptiles and birds and submitted an arrangement to show the probable relationship of the reptilian and avian amphistomes to those of other vertebrates. The amphistomes of fishes had been studied by Daday (1907), those of frogs by Cohn (1904) and Johnston (1912), while the mammalian species had been the subject of extensive papers by Fischoeder (1903) and Stiles and Goldberger (1910). Many of the descriptions were fragmentary, knowledge of the forms was incomplete, and the classification of Stiles and Goldberger was received with severe criticism, especially by Braun (1911), Odhner (1911) and Looss (1912). In this paper Looss described the lymphatic systems of *Schizamphistomum scleroporum* and *Paramphistomum gigantocotyle*, and announced (p. 358) that for many years he had been engaged in preparing a classification of the amphistomes which would be based on the form of the lymph and excretory systems and the structure of the copulatory apparatus[1].

More recently Maplestone (1923) has attempted a revision of the amphistomes of mammals. His work is based on the collections of the Liverpool School of Tropical Medicine and a large amount of material was available for study. This assemblage according to Maplestone consisted of sixteen species belonging to the ten genera, *Paramphistomum*, *Cotylophoron*, *Pseudodiscus*, *Stephanopharynx*, *Gastrothylax*, *Fischoederius*, *Carmyerius*, *Gastrodiscus*, *Gastrodiscoides*, and *Brumptia*. Noting wide variation in the size and position of the digestive and reproductive organs in these species and making a critical study of the monographs of Fischoeder and Stiles and Goldberger, he concluded that "many of the species described by the former and all except one

[1] Looss stated: "Jeder Klassifikationsversuch, der der Bau von Excretions- und Lymphgefässsystem ausser acht lässt, mag sich wohl einen Klassifikationsversuch nennen, kann aber niemals Anspruch darauf erheben, als natürlicher oder (was dasselbe ist) wissenschaftlicher Klassifikationsversuch anerkannt zu werden."

of those described by the latter authors, are merely synonyms of earlier species." Referring to previous classifications he stated that "the confusion caused by Stiles and Goldberger's multiplication of genera, etc., still exists. Stunkard (1917), in a resumé of the group, makes a 'provisional' attempt at reclassification, but as he did not examine any material except three or four species from American fish, for which he makes two new genera, he is unable to discuss whether many of the existing species and genera are valid or not." Had the author read my paper, which is at least expected of one who attempts to pass judgment, he would have known that none of the species studied came from fish. The worms there described infest reptiles and birds and the "tentative" revision was based on the published opinions of Braun, Odhner and Looss, able investigators and the foremost authorities on the taxonomy of the trematodes. As declared at the time, I had made no first hand study of the amphistomes of mammals or fish, consequently no attempt was made to pass judgment on the validity of described genera or species and they were included without comment. The tentative arrangement was prepared awaiting the appearance of Looss' classification of the amphistomes. Unfortunately this work was interrupted as a result of his departure from Cairo and was not published before his death.

The revision presented by Maplestone is designated a "working classification" of the Amphistomata of mammals and presents a system for identifying the known forms. The larger groups are separated on the basis of a single arbitrary distinction with complete indifference to other anatomical features and the genera and species are in most instances inadequately characterized. The work admittedly, p. 115, "does not take cognizance of the standards required by the more advanced systematists such as Looss and Odhner." The statement of Looss that the character of lymph and excretory systems and the structure of the copulatory apparatus are to be considered as the most important features in the classification of the amphistomes was dismissed with the comment, p. 114, that "it appears too complicated for practical purposes." In his anatomical and taxonomic discussions the lymphatic system is not even mentioned, only the terminal vesicle of the excretory system is described, and the morphology of the copulatory organs is not thoroughly treated. Referring to the observation that the genital papilla when protruded obliterates the genital atrium and when retracted may manifest a hermaphroditic duct, he says, p. 194, "the presence or absence of a prominent genital papilla, or of a genital atrium, are purely matters of chance, and are of no more diagnostic value in this instance (*Gastrodiscoides hominis*) than in any other species of the Amphistomata." This statement illustrates the confusion prevalent throughout the paper between physiological variations due to degrees and states of functional activity and true structural differences. On the other hand, his examination and analysis of the relations between Laurer's canal and the excretory vesicle are praiseworthy and the union of Fischoeder's sections A and C of the genus *Paramphistomum* appears entirely justified. In not all

instances however are sufficient data given to substantiate the conclusion that different species are identical. The explanation of structural differences as due to differences in age and development is sometimes overworked, notably in the statement that "*Pseudodiscus stanleyi* is therefore only an immature form of *Pseudodiscus collinsi* and must be regarded as synonymous with the latter." And this notwithstanding the fact that the specimens of *P. stanleyi* are about one-third larger than those of *P. collinsi*. Although it is quite probable, as pointed out by Cobbold, that the two forms are the same, the argument of Maplestone is far from convincing. *Cotylophoron sellsi* Leiper, 1910, was listed as a synonym of *C. minutum* Leiper. In this case Maplestone's comparison of the two species appears superficial and his conclusion erroneous. According to the description of Leiper, *C. sellsi* is more than twice as large as *C. minutum*, the testes and ovary are about four times as large, whereas the oral and ventral suckers are actually smaller than those of *C. minutum*. It seems incredible that these differences are mere variations and therefore I am in agreement with Leiper in regarding the two forms as distinct species.

Discussing the diagnosis of the genus *Pseudodiscus* Maplestone pointed out that in *P. collinsi* the testes are side by side, whereas in *P. hawkesii* they are situated one in front of the other. Calling attention to the agreement between *P. hawkesii* and *Watsonius watsoni* he argued that the two forms are possibly identical, at least they must be included in the same genus and consequently *Watsonius* becomes a synonym of *Pseudodiscus*. The argument is logical and the conclusion sound if *P. hawkesii* can be included in the same genus with *P. collinsi*. Of this I think there is a reasonable doubt. Stiles and Goldberger's figures of *P. collinsi* indicate that whether the worms are young or mature the testes are always at the same level on opposite sides of the body, whereas in the species *hawkesii* and *watsonii* they are median, one before the other. This in my opinion indicates generic difference and I would therefore restore the genus *Watsonius* for the species *watsoni* and *hawkesii*.

On the other hand, certain species regarded as valid are clearly alike and evince no distinctive traits when Maplestone's own criteria are applied to them. In the genus *Carmyerius* the species *synethes*, *minutus*, *mancupatus*, *bulbalis*, and *wellmani* are listed as identical with *C. spatiosus*, whereas *C. wenyoni* and *C. cruciformis* are considered good species. An examination of the case shows that *C. wenyoni* is distinguished by the union of the excretory and Laurer's canals and that they open by a common pore. In other respects the form is similar to *C. spatiosus*. Now the original description of *C. wenyoni* states that only a single specimen was sectioned and consequently the union of the two ducts was observed but once. In the discussion of *P. cervi*, Maplestone emphasized the variation in relations between these canals and since in *C. spatiosus* (Fischoeder's Fig. 51) the two open very close together, it would be conceivable that occasionally they might unite. It appears that the validity of *C. wenyoni* can be established only when examination of other

specimens has shown the union of the two ducts to be a common and constant feature. Concerning *C. cruciformis*, the statement is made that "This worm is essentially the same as *C. spatiosus* in details of anatomy, but is easily distinguished from that species by its minute size even in the gravid state." Maplestone's specimens of *C. cruciformis* containing eggs in the uterus measured from 5 to 7 mm. in length. On the same page he argued that *C. minutus* Fischoeder is a synonym of *C. spatiosus*. According to Fischoeder, specimens of *C. minutus* vary between 3 and 7 mm. in length, the majority measuring from 4 to 5 mm. Since he gave the size of the eggs the specimens must have been sexually mature. If *C. minutus* is a synonym of *C. spatiosus*, *C. cruciformis* is also a synonym of that species and the position of Maplestone utterly untenable. In addition to the incongruities regarding synonymy and validity of species, one further item deserves mention. Discussing Fischoeder's division of the genus *Gastrothylax* using the shape of the ventral pouch on cross section as the distinguishing feature, Maplestone devoted considerable space in the text and twenty-seven figures, sixteen of *Gastrothylax crumenifer* and eleven of *Carmyerius spatiosus*, to show that the ventral pouch "may assume almost any shape and cannot be regarded as of any use in diagnosis." Nevertheless, a few pages later, in the description of *Carmyerius exoporus* n.sp. he gave nineteen figures to show the shape of the ventral pouch which he stated "is somewhat characteristic in some cases."

Careful study of the taxonomic portion of the work dealing with the larger groupings discloses not only an astounding disregard for the recent studies on a natural system of trematode classification, but also certain inconsistencies that in large measure invalidate the conclusions. The genera *Carmyerius* and *Fischoederius* are distinguished in that the former has testes side by side while in the latter these organs are situated in the midline, one dorsal of the other. In the genus *Cladorchis*, however, the species *pyriformis* and *asper* in which the testes are in tandem arrangement are included together with the species *giganteus* and *subtriquetrus*, in which the testes are situated side by side. For these two latter species Fischoeder proposed the subgenus *Stichorchis*, which should not only be retained but regarded as of generic rank and equal in value with *Carmyerius* or *Fischoederius*. Another instance of this kind has been discussed in the case of *Pseudodiscus*.

For the single species *Stephanopharynx compactus* he would recognize the subfamily Stephanopharynginae, making it of equal rank with the Paramphistominae and Cladorchinae. These three groups are distinguished on the basis of a single feature, the number of oral evaginations. In the Paramphistominae they are lacking, in the Cladorchinae they are paired, and in *Stephanopharynx* there is a single median sac. In the Cladorchinae, however, there are several species in which the sacs are so reduced that they are enclosed within the muscular wall of the sucker and almost indistinguishable. Within the group there is every gradation from this rudimentary or vestigial condition to large sacs exceeding the sucker in size. Slightly more reduction would give the

condition characteristic of *Paramphistomum* and the median migration and fusion of the sacs would produce the single median evagination of *Stephanopharynx*. It would seem therefore that the number of oral sacs, while obviously a convenient means of separating forms, is not of fundamental and primary importance in the formulation of a natural system of classification. The erection of a subfamily to contain *Stephanopharynx* serves no useful purpose; the presence of a single oral sac in this form is probably of no more significance than the presence of a genital sucker in *Cotylophoron* and since in other respects these genera are so similar to *Paramphistomum*, they should for the present at least be included with it in the subfamily Paramphistominae.

Although a subfamily is proposed for *Stephanopharynx* distinguished only by a single oral sac, other forms that manifest the most diverse structural differences are included in the subfamily Cladorchinae. Conspicuous in its anatomical differences the genus *Balanorchis* stands as a monstrosity disturbing the morphological unity of the group. Fischoeder (1903) stated that differences in habitat and in body structure definitely excluded it from the Cladorchinae[1]. In this form alone among the amphistomes are the ovary and uterus pretesticular, and these features together with its characteristic vitellaria, testes, and copulatory apparatus not only exclude it from the Cladorchinae, but as pointed out in my earlier paper (1917) outline a new subfamily of which it is the type. The subfamily Balanorchinae should be formally erected.

The subfamily Diplodiscinae Cohn was suppressed with the single comment: "This subfamily has two oral diverticula and has no constant characters by which it may be distinguished from Cladorchinae." Such arbitrary treatment of a subfamily is hardly in accord with proper scientific procedure, especially since the anatomy of the forms is so imperfectly known. Only after a complete knowledge of the lymph and excretory systems is available would it be possible to make so sweeping a statement. It has been pointed out before (Stunkard, 1917) that Cohn's diagnosis of the group is inadequate, and that further study is necessary to determine its true distinguishing characters, but nevertheless the subfamily is probably valid and it appears better to accept it than expand the subfamily Cladorchinae to include such different forms as *Diplodiscus*, *Catadiscus*, and *Opisthodiscus*.

In the genera *Gastrodiscus*, *Gastrodiscoides*, and *Homalogaster* the body is divided into anterior and posterior portions, one of which is usually flattened. Maplestone would accord family rank to the group containing these genera as well as to the group containing the three genera *Gastrothylax*, *Fischoederius*, and *Carmyerius*, characterized by the presence of a ventral pouch. He advanced no argument to justify such a procedure or to show why each of these groups is of the same taxonomic value and rank as the remainder of the

[1] "Diese Gattung ist zwar ebenfalls durch den Besitz von Pharyngealtaschen ausgezeichnet, weicht jedoch im Uebrigen nicht nur in Bezug auf den Wohnsitz, sondern auch in seinem ganzen Bauplane so wesentlich von den Cladorchinen ab, dass sie diesen nicht eingereiht werden kann, sondern vorläufig isolirt stehen bleiben muss."

mammalian amphistomes. As pointed out by Odhner (1911), in essential organization and character of the organ systems these forms are typical amphistomes, similar to the Paramphistominae and Cladorchinae, and until adequate evidence is submitted to justify their elevation to family rank, they should be regarded as subfamilies in the family Paramphistomidae.

In order to maintain his thesis that differences in body form are of family significance, Maplestone would be compelled to erect a new family for *Brumptia gigas*, included as an appendix to his classification under the heading "genus of uncertain position." Actually, his suspicion that the form could not be retained in the Cladorchinae was well founded; my own studies on abundant material of the species have convinced me that it can not be included in any existing group and that undoubtedly it represents a new subfamily. The morphological features peculiar to the genus *Brumptia* may be taken as diagnostic of the subfamily Brumptinae. When other members are discovered the diagnosis should be emended accordingly.

The value of Maplestone's revision would have been greatly augmented had he related the amphistomes of mammals to those of other vertebrates. Patently these worms are related and a classification of the parasites of certain hosts can hardly be considered adequate or complete in itself when it ignores their congeners in other hosts. The revision is apparently designed to facilitate the identification of previously described forms and no claim is made that the arrangement constitutes a natural system of classification, that it represents relationship, or that it forms a contribution to the phylogeny of the groups concerned. Essentially what the author has done is to relegate to synonymy two generic and some thirty specific names, and resurrect in virtually its original form the classification of Stiles and Goldberger. In the recognition of specific identity the author has performed a very valuable service and the synonymy determined is probably correct in most instances. I have pointed out that other species, *Carmyerius cruciformis* and possibly also *C. wenyoni* are not valid and these names should be added to the list of synonyms. On the other hand, the restoration of Stiles and Goldberger's system of classification does not appear to be justified. The elevation of the Gastrodiscinae and Gastrothylacinae to family rank is not supported by zoological data. I am inclined, for the present at least, to accept the opinion of Braun and Odhner, stated by the latter (1911) as follows: "die Amphistomen entsprechen im systematischen Range einer einzelnen Distomenfamilie und nicht, wie Stiles und Goldberger geglaubt haben, der Summe sämtlicher dieser Familien." Using published descriptions of Maplestone and previous authors, supplemented by my own studies of amphistomes from amphibians, reptiles, birds, and mammals, I have attempted to rectify the taxonomic portion of the work.

Of the American amphistomes, *Wardius zibethicus* Barker and East from the caecum of the musk rat was included (Ward, 1918) as representing a good genus in the subfamily Cladorchinae. The original account is merely a pre-

liminary description, an abstract of research, and the complete report has not yet appeared. The form is similar to *Watsonius watsoni*.

Lane (1924) repeated his earlier objection to the erection of the genus *Gastrodiscoides*, and referred *G. hominis* again to the genus *Gastrodiscus*. He discussed (1) the presence of a genital cone, (2) position of genital orifice, (3) smooth ventral disc, and (4) "testes tandem," characters selected by Leiper as distinguishing the genus *Gastrodiscoides*. Leiper described and figured a prominent genital papilla. Maplestone gave two figures, one of a specimen in which such a papilla is present and another of a specimen in which the uterus and vas deferens open separately into a deep genital atrium. Lane finding no cone, but a depression surrounded by a tuberculated area encircling the opening of the genital atrium in sections of Lewis and McConnell's "type" material, concluded that, "*G. hominis* may show either a genital cone or genital depression, and that it possesses certain anatomical muscular dispositions clearly capable of producing these alterations in the fluke's profile." Concerning the position of the genital pore, Lane pointed out that this orifice cannot be definitely located with reference to the cephalic edge of the disc since "Of the three specimens which Lane illustrates, the anterior rim of the disc is ventrally marked in one, indefinite in one, absent in one." Neither can it be located with reference to the internal anatomy since "Maplestone has shown that the position of the genital pore in front of or behind the gut fork is not even of specific value in this group." Although the distinction between anterior cone and disc is indefinite Lane says, "the line of junction of cone and disc may be roughly established by the lateral and dorsal aspects. Thus judged, Lane illustrates in Lewis and McConnell's material the anterior portion as occupying 3·5 out of 7 mm.; Khalil as 2 out of 7 mm. The anterior edge of the disc is then a point of varying position and particular indefiniteness in *G. hominis*, and one not affording a basis for generic distinctions."

With reference to the prominences present on the ventral surface of the disc in *G. aegypticus*, Lane recalls that according to Looss they depend upon the disposition of a special group of ventral muscles and upon contraction of the body or of these particular muscles. He says, "It scarcely requires reiteration that neither genus or species can rest on shape induced by muscular contraction." Discussing the position of the testes, Lane observed, "The anterior testis may in undistorted specimens lie in the disc or more or less in the cone, the other testis lying axially behind it; in squash preparations the other testis may readily be made to take an oblique position. In other words, their relative position is alterable with methods of examination, and cannot be made a generic character." It appears, therefore, that the genital papilla, the ventral prominences, the relation of the genital pore to the anterior edge of the disc, and the position of the testes are data insufficient to justify the creation of the genus *Gastrodiscoides*.

The examination of large numbers of specimens of both *G. aegypticus* and *G. hominis* permits me to comment on Lane's observations. Both Lane and

Maplestone have apparently been misled by the failure to realise that the trematodes are soft bodied animals capable of much change of form as different sets of muscles are contracted, and also through the inability to distinguish between functional and structural differences. In *G. hominis* I have observed a large genital prominence formed by the musculature surrounding the pore in certain individuals that may be reduced or entirely lacking in others. The presence or absence of a genital papilla is due to the state of muscular contraction in the copulatory apparatus of the particular specimen at the time it was killed. I am quite convinced that among Lewis and McConnell's type material there are specimens that manifest a genital papilla. Consequently, I am inclined to agree with Lane that the presence of a genital cone cannot be used as a generic feature. The same is not true for the position of the testes which vary somewhat with body movements and of course may be pushed about by violent methods of examination. Data taken from such mutilated specimens can hardly be accepted as correct or valid, and these organs have a definite location and tandem arrangement in the body. In relative size, shape, and form the disc of *G. hominis* differs decidedly from that of *G. aegypticus*. Lane's observation that "The anterior edge of the disc is a point of varying position and particular indefiniteness" is a point in question. The anterior portion of the body is almost as long as the region bearing the disc and the relative length of portions is due, not to a migration of the anterior margin of the disc, as believed by Lane, but to the extension and retraction of the cephalic portion of the body. When this anterior portion is prolonged the disc tends to become arched and its anterior margin is distinguishable; when the region is retracted it produces a bulging ventrally as well as dorsally, obliterating the cavity and the anterior rim of the disc. In this condition the body may manifest only a pair of lateral flanges, interrupted posteriorly and anteriorly. The lateral edges of the disc are relatively thicker and more muscular in *G. hominis* and in contracted specimens viewed from the ventral surface, they may appear as conspicuous lateral crescents. In *G. hominis* the disc does not extend as far forward as in *G. aegypticus*, *i.e.*, it is present on relatively less of the body. As a consequence the disc is almost circular and frequently broader than long. In these respects the disc of the two species manifests true and important anatomical differences. Another striking difference is in the location of the genital pore. In *G. aegypticus* it lies within the disc near its anterior margin, in *G. hominis* it lies in front of the disc near the middle of the cephalic cone. The particular set of muscles, so highly developed in *G. aegypticus* and which in that species are associated with the presence of the ventral protuberances, are reduced or absent in *G. hominis* with the result that these papillae do not appear. The question of difference is then not one of muscular contraction as supposed by Lane, but of muscular development, and the reduction of these muscles together with the absence of ventral papillae constitute a further distinct structural difference between the two species. *G. hominis* differs from *G. aegypticus* in

position of testes, in location of the genital pore, in the relative size, shape and form of the disc, in the development of ventral musculature and in the absence of ventral papillae. These differences in my opinion are of generic importance and consequently I regard *Gastrodiscoides* as a valid genus.

More complete knowledge regarding amphistome structure and the extent of variation within species makes it possible to profitably review the forms described from lower vertebrates. The work of Daday (1907) on the amphistomes of fishes deserves attention. This author described two new species of *Diplodiscus*; included in a new genus *Microrchis* the species *Amphistoma megacotyle* and *A. ferrum-equinum* of Diesing, 1838; erected another new genus *Pseudocladorchis* to contain *A. cylindricum* Diesing and two new species, *P. nephrodorchis* and *P. macrostomus*; and to the genus *Chiorchis* he added *A. oxycephalus* Diesing, *A. lunatum* Diesing, and two new species, *C. dilatatus* and *C. papillatus*. The diagnoses of the three genera are inadequate and confused in certain particulars. This can be explained in large measure by a careful study of the species included. In *Microrchis megacotyle* the ovary and testes are in the anterior half of the body and the vitellaria are nearer the anterior than the posterior end. Laurer's canal and the excretory vesicle open almost if not quite together in the mid-dorsal line, midway between the anterior and posterior ends of the body. In *M. ferrum-equinum* the entire complex of reproductive organs is much farther caudad than in *M. megacotyle*, Laurer's canal opens dorsal to the ovary at the level of the posterior third of the body, and the excretory vesicle opens about midway between the opening of Laurer's canal and the acetabulum. Where *M. ferrum-equinum* differs from *M. megacotyle* it agrees with *A. cylindricus*, named as type of the genus *Pseudocladorchis*. One seeming point of difference is that in *ferrum-equinum* the testes are smooth, whereas in *cylindricus* they are more or less lobed, but this difficulty will be discussed presently. In other respects morphological agreement necessitates the transfer of *ferrum-equinum* from the genus *Microrchis* to *Pseudocladorchis*. It is even possible that further studies will show these two genera to belong in a single genus. In that event *Pseudocladorchis* will disappear as a synonym of *Microrchis*.

A comparison of *Pseudocladorchis cylindricus*, *P. nephrodorchis*, and *P. macrostomus* shows no lines of specific demarcation. The study of any organ in the three species presents a continuous series of variations; the testes vary from smooth to reniform to irregular to lobed; and the forms intergrade so completely that specific distinctions cannot be distinguished. Consequently they must be regarded as the same species and the names *nephrodorchis* and *macrostomus* disappear.

The inclusion of the several species in the genus *Chiorchis* cannot be regarded as a natural or proper arrangement. In generic features not one of them agrees with *Chiorchis fabaceous* type of the genus. The writer (1917) removed *Amphistoma lunatum* to the genus *Zygocotyle*. *Amphistoma oxycephalus* differs from *C. fabaceus* in the position of acetabulum and excretory

pore, position and form of testes, and extent of vitellaria. This species cannot belong to the genus *Chiorchis*. In no feature so far as the description of Daday is explicit does it manifest generic difference from *P. cylindricus* and they should be placed in the same genus. *Pseudocladorchis oxycephalus* has testes far forward like *Microrchis megacotyle*, another feature linking the two genera, but in the former species the ovary is farther caudad and the excretory vesicle opens near the anterior margin of the acetabulum. The form described as *Chiorchis papillatus* is clearly a synonym of *P. oxycephalus*. An examination of Daday's description and figures removes any doubt on this point. The only differences discoverable by the author were histological ones that do not commend themselves as real or valid for specific distinction. His figure of "Gepaarte Exemplare," Plate 29, is amusing since it represents not conjugating individuals but two worms in which the oral sucker of one has been seized in the acetabulum of the other. The single worm described as *Chiorchis dilatatus* apparently represents a new and valid species but does not belong to the genus *Chiorchis* and should be transferred to *Pseudocladorchis*. Likewise the two species *pangasii* and *helostomatis* described by MacCallum (1905) from Sumatran fishes should be removed from the genus *Cladorchis* to *Pseudocladorchis*. This genus contains then the following species, *cylindricus* Dies., *ferrum-equinum* Dies., *oxycephalus* Dies., *dilatatus* Daday, *pangasii* MacCallum, *helostomatis* MacCallum, and probably also *guadrangulatum* Daday (for the last species see Odhner, 1911).

Schizamphistomoides new genus.

Among the amphistomes from reptiles, *Schizamphistomum spinulosum* Looss deserves consideration. The structure and systematic position of this species I discussed at length in an earlier paper (1917, pp. 64–65). Evidence was there submitted to prove that this species cannot be retained in the genus *Schizamphistomum* and for it I propose a new genus *Schizamphistomoides*[1].

A comprehensive survey of the amphistomes shows that they constitute a well-defined, clearly-outlined group. Nine subfamilies may be recognized: (1) Diplodiscinae Cohn 1904 comprising the genera *Diplodiscus*, *Catadiscus*, and *Opisthodiscus*; (2) Schizamphistominae Looss 1912 with the genera *Schizamphistomum*, *Schizamphistomoides*, *Alassostoma*, and *Allassostomoides*; (3) Cladorchinae Fischoeder 1901 containing the genera *Cladorchis*, *Pseudocladorchis*, *Microrchis*, *Taxorchis*, *Stichorchis*, *Chiorchis*, *Pfenderius*, *Pseudodiscus*, *Watsonius*, and *Wardius*; (4) Paramphistominae Fischoeder 1901 including the genera *Paramphistomum*, *Cotylophoron*, and *Stephanopharynx*; (5) Gastrodiscinae Monticelli 1892 comprising the genera *Gastrodiscus*, *Gastrodiscoides*, and *Homalogaster*; (6) Gastrothylacinae Stiles and Goldberger 1910

[1] The two species, *Paramphistomum papillosum* MacCallum 1916 (*Zoopathologica*, I, pp. 31–33, Fig. 13) from the colon of *Chelonia mydas*, and *Paramphistomum aspidonectes* MacCallum 1917 (*idem*, I, pp. 59–60, Fig. 26) from the oviduct of *Trionyx spinifer* do not belong to the genus *Paramphistomum*, but the descriptions are so imperfect that it is not feasible to attempt a generic disposal of them.

with the genera *Gastrothylax*, *Fischoederius*, and *Carmyerius*; (7) Zygocotylinae Stunkard 1916; (8) Balanorchinae Stunkard 1917; and (9) Brumptinae Stunkard (the present paper), each of the last three subfamilies at present known by a single genus.

The Diplodiscinae, Schizamphistominae, and Cladorchinae are generalized, typical forms, in large measure parasitic in the terminal portion of the intestine of lower vertebrates. The Zygocotylinae are parasitic in birds and the other five subfamilies are parasitic in mammals. The forms that infest the higher or homothermal vertebrates are more highly specialized, more divergent, and represent radiation from a more simple, primitive stock. Consideration of a single feature may serve to illustrate this: The oral sacs, conspicuous structures in the group, are paired in the parasites of the lower vertebrates and in those of many of the higher forms. This may be regarded as the typical, primitive condition. They are reduced in certain genera; in the genus *Stephanopharynx* they have united to form a single median sac, while in other genera of the Paramphistominae and in the Gastrothylacinae they have entirely disappeared. The form of the organ systems is similar throughout the amphistome group with variations from the common plan appearing in the different subfamilies. These groups appear of coequal rank; the flattened body of the Gastrodiscinae or the ventral pouch of the Gastrothylacinae is of no greater significance than the peculiar shaped body of *Brumptia* or the singular arrangement of the reproductive organs in *Balanorchis*. The subfamilies do not naturally unite into separate groups but constitute a more or less continuous series of similar and related units in a single group. No one of the subfamilies alone appears worthy of elevation to family rank and since they have so many features in common, such a removal would appear unnatural. With present incomplete knowledge of the excretory and lymph systems it is impossible with certainty to group the subfamilies into higher units within the Amphistomata and for the present at least all should be included in a single family, the Paramphistomidae.

In his admirable studies on a natural classification of the digenetic trematodes, Odhner has dealt in an acute and comprehensive manner with the morphology and homologies of the various groups. Comparing the monostomes of the family Angiodictyidae Looss with different amphistomes he (1911) submitted a convincing argument that these forms are really amphistomes in which the acetabulum has been lost[1].

[1] Odhner (1911, p. 189): "Die Angiodictyiden sind also, um zu unserm Hauptthema wiederzukehren, aus der zerfallenden Monostomengruppe auszuscheiden und den Amphistomiden im System anzureihen. Ich bin sogar der Meinung, dass sie als eigne Familie nicht mehr aufgeführt werden können, sondern als Unterfamilie in die Familie Amphistomidae einzureihen sind. Der Mangel des hinteren Saugnapfes und die netzförmige Ausbildung der Excretionsblase sind nicht genügende Merkmale, um das Aufrechterhalten einer besonderen Familie zu rechtfertigen. Stellt man dagegen den Amphistomiden im herkömmlichen Sinne mit den Angiodictyiden zusammen, so bekommt man eine sehr hübsch geschlossene natürliche Familie, wie man sie nicht besser verlangen kann."

Looss had previously noted the similarity between these forms and (1912) agreed with Odhner that they are undoubtedly closely related, although due to the insufficient knowledge of the amphistomes he hesitated to include them in the same family. The Amphistomata may ultimately be found to comprise more forms than the single family Paramphistomidae, but it will be only when the angiodictyids and possibly other amphistome derivatives are known and properly arranged therein.

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(*MS. received for publication,* 14. x. 1924.—Ed.)

ACANTHOCEPHALA FROM JAPAN[1].

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(With 11 Text-figures.)

There are no published records of the occurrence of Acanthocephala in the vertebrates of Japan. Professor Seitaro Goto has very kindly sent me a small collection of these worms for identification. While the collection is not extensive, it seems worth while to publish the results of the investigation, especially since there are several new species and a considerable amount of new biological data. In the ten vials of materials contained in this consignment, but seven host species are represented. Four of these are amphibians, two are fishes, and one is a whale. The parasites which these harboured include four new species of the genus *Acanthocephalus*, a previously undescribed member of the genus *Arhythmorhynchus*, a species of the genus *Echinorhynchus* and one unidentified species each in the genera *Bolbosoma* and *Centrorhynchus*.

Genus **Acanthocephalus.**

Sexually mature representatives of the genus *Acanthocephalus* occur in the digestive tract of amphibians and fishes. Members of this genus always present a monotonous similarity of body form and general organisation. The surface of the body is smooth, without cuticular adornments of any sort, and the cylindrical proboscis, while it varies in proportions and in actual size, lacks distinctive character. Most of the specific distinctions within this genus are based upon characters furnished by the proboscis hooks and by the embryos within the body cavity of the gravid females.

The number and disposition of the proboscis hooks seem to have great value in the diagnosis of species within other genera of Acanthocephala but in this genus *Acanthocephalus* the numbers of hooks are so highly variable that they furnish characteristics of only secondary importance (Lühe, 1912). Lühe has demonstrated that in two European species of this genus from Amphibia (*A. ranae* and *A. falcatus*) a distinction is impossible on the basis of the numbers of longitudinal rows of hooks upon the proboscis, for variability in the two species is such that ranges in the numbers of rows overlap for the two species. In *A. falcatus*, there are 12 to 14 longitudinal rows of hooks while in *A. ranae* there may be any number of rows from 13 to 19.

[1] Contributions from the Zoological Laboratory of the University of Illinois, No. 249.

However, Lühe has shown that these two species are rather readily differentiated upon the basis of the size of the proboscis hooks. He has also emphasised the fact that the latter of these species is characteristically a parasite of the Anura while *A. falcatus* is normally met only in the Urodeles.

Unfortunately, neither Lühe nor any other European investigator has given data concerning the possibility of differentiating these two species through measurements of the embryos within the body cavity of gravid females. Lühe was familiar with the possibilities of this characteristic for he has utilised it wisely in many of his specific differentiations. In his earlier work (1911), he cited measurements for the embryos of *A. ranae* but in no place have I been able to find measurements given for the embryos of *A. falcatus*. In view of the fact that Lühe so frequently made use of this criterion for differentiating species, either the specimens of *A. falcatus* which came to his attention were not fully mature or possibly the embryos were of the same size as those found in *A. ranae* and consequently of no value in differentiating the two species. On no other grounds can the present writer explain Lühe's failure to utilise a criterion of distinction which he so commonly employed in the remainder of his researches.

The means of differentiating *A. ranae* and *A. falcatus* of European hosts are enumerated here because of a striking similarity which exists between their relationships and those of the species of this same genus found in Urodeles and Anura of Japan. In the following table, which presents the data giving the evidence of this parallelism, *Acanthocephalus anthuris*, another European species from Urodeles is omitted because of the inadequacy of the available information concerning it.

Table I.

Comparison of European and Japanese species of the genus Acanthocephalus *from Amphibians.*

			Proboscis hooks		
				Length in μ embryos	
Normal hosts	Parasite	Distribution	Longit. rows		
Urodeles	*A. falcatus*	Europe	12–14	25–65	?
Urodeles	*A. nanus*	Japan	10–12	48–60	77–94 × 9–12
Anura	*A. ranae*	Europe	13–19	50–80	110 × 18
Anura	*A. lucidus*	Japan	12–16	70–94	94–106 × 24–26
Anura	*A. artatus*	Japan	14–16	90–100	69–83 × 18–24

From the evidence presented above, it seems that the proboscis hooks of the Anuran parasites of this genus are distinctly more numerous and are very markedly longer than those of the parasites of Urodeles.

The close parallelism between the European and Japanese representatives of the genus *Acanthocephalus* provides evidence for some interesting speculations regarding the evolution of these parasites along with the evolution of their hosts.

Acanthocephalus nanus sp. nov.

(Figs. 2, 5, and 6.)

Males usually about 5 mm. long, with a maximum diameter of 0·6 to 0·8 mm.; females 8 to 11 mm. long, with a maximum diameter of 0·7 to 0·9 mm. Proboscis cylindrical, usually 0·4 mm. long by 0·18 mm. in diameter, armed with 10 to 12 longitudinal rows of six to eight hooks each. Hooks at base of proboscis 47 to 53 μ, at the tip 41 to 47 μ, remainder 53 to 59 μ. Proboscis receptacle 0·18 mm. long. Lemnisci about one and a half times the length of the receptacle. Type (♀) has a proboscis 0·35 mm. long and 0·18 mm. in diameter. Embryos within body cavity of gravid females 77 to 94 μ long by 9 to 12 μ in diameter.

Type host, *Diemictylus pyrrhogaster* taken in Province Ômi, Japan, August, 1920.

Type (♀) and allotype (♂) in collection of the writer at Urbana, Illinois. Paratypes in same collection and in collection of S. Goto.

More than twenty specimens of this species were available for study but many of them were in poor state of preservation.

Acanthocephalus lucidus sp. nov.

(Fig. 1.)

Males about 4 mm. in length, females 12 to 17 mm. Proboscis of type male 0·35 mm. long and 0·3 mm. in diameter. 12 to 16 longitudinal rows of proboscis hooks, four in each row; those at tip slightly smaller and shorter (70 μ) than those on remainder of proboscis (82 to 88 μ). Lemnisci but slightly longer than proboscis receptacle. Embryos from body cavity of gravid females 94 to 106 μ long and 24 to 26 μ in diameter.

Type host, *Rana japonica*; Province Shimosa, Japan, September, 1920.

Type in the collection of the writer at Urbana, Illinois. Paratypes in same collection and in collection of S. Goto.

This species, which superficially very closely resembles the following species, is readily distinguishable on the size and shape of the embryos and size of the proboscis hooks. In most of the females the embryos were so tightly packed within the body cavity that it was necessary to puncture the body wall of an alcoholic specimen and then mount the discharged embryos in alcohol upon a slide. Under these conditions very accurate measurements could be secured.

Acanthocephalus artatus sp. nov.

(Fig. 4.)

Body of mature individuals about 10 or 11 mm. long. Proboscis at least partly obscured in all specimens available, length not obtainable, diameter about 0·27 mm., form apparently similar to that shown for *A. lucidus* (Fig. 1). Armed with about 14 to 16 longitudinal rows of four or more hooks each;

those near the base of proboscis about 90 μ long, near the middle about 100 μ. Embryos 69 to 83 μ long and 18 to 24 μ in diameter.

Type host, *Rana japonica* from Province Shinano, April, 1920.

Cotypes in the collection of the writer at Urbana, Illinois, and in the collection of S. Goto.

The description of this species is based upon a study of six individuals all of which have the proboscis retracted or inverted. The species seems to be closely allied to *A. lucidus* from which it may be differentiated readily because of specific differences in the sizes of the embryos.

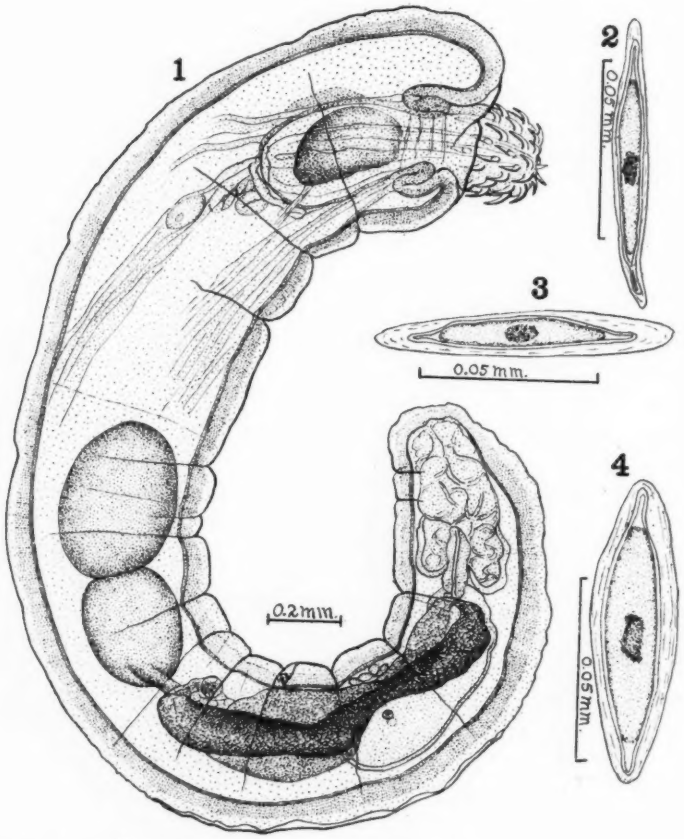


Fig. 1. Male of *Acanthocephalus lucidus* sp. nov. (type individual).

Figs. 2 to 4. Embryos of the genus *Acanthocephalus* drawn to the same scale of magnification. Fig. 2. Embryo of *Acanthocephalus nanus* sp. nov. Fig. 3. Embryo of *Acanthocephalus gotoi* sp. nov. Fig. 4. Embryo of *Acanthocephalus artatus* sp. nov.

Acanthocephalus gotoi sp. nov.

(Figs. 3, 7 and 8.)

A single female 7·2 mm. in length and two males about 5 mm. long served as the basis for the description of this species. Proboscis tapering very slightly towards the tip, about 0·6 mm. long and 0·2 mm. in diameter near the middle. Armed with 15 to 17 (or more?) longitudinal rows of about 15 hooks each. Hooks upon different regions of proboscis not greatly different in size, about

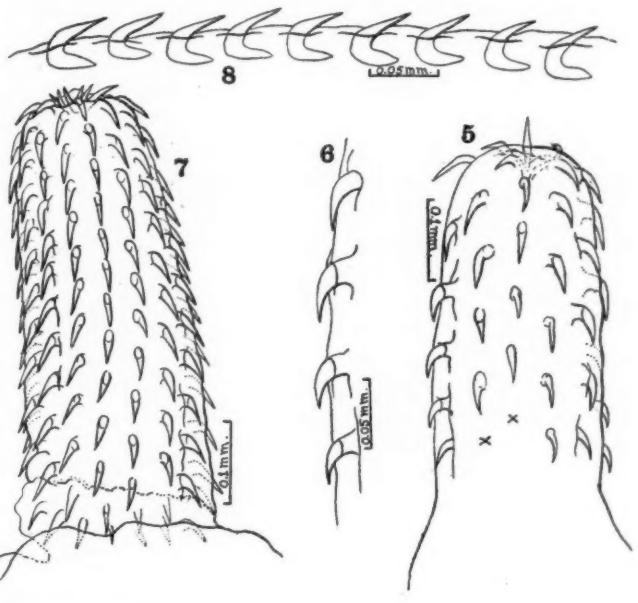


Fig. 5. Proboscis of *Acanthocephalus nanus* sp. nov. "X" locates position of a broken hook.
Fig. 6. Profile showing a single row of hooks from the proboscis of *Ac. nanus*.
Fig. 7. Proboscis of *Acanthocephalus gotoi* sp. nov.
Fig. 8. Profile showing a portion of a single row of hooks from the proboscis of *Ac. gotoi*.

47 to 53 μ long. Embryos within body cavity of gravid female spindle-shaped, very long and narrow, 71 to 83 μ long by 9 to 12 μ in maximum diameter.

Type host, *Anguilla japonica* from Tokyo fish market in January, 1921.

Type (♂) and allotype (♀) in collection of the writer at Urbana, Illinois. Paratype (♂) in collection of S. Goto.

? *Echinorhynchus gadi* Müller, 1776.

Six specimens from the intestine of *Oncorhynchus mason* (Tokyo, May, 1887) have been tentatively assigned to the broadly distributed species, *Echinorhynchus gadi* of holarctic marine fishes. In all of the available speci-

mens, the proboscis is withdrawn into the body and consequently is not observable for the essential specific characters. Embryos which also furnish specific characters are wanting because all of the females are immature. The tentative determination is based upon the characters of the male genitalia. The cement glands and the testes are identical with those of *E. gadi*.

Genus **Arhythmorhynchus.**

Adult representatives of the genus *Arhythmorhynchus* have been recorded from avian hosts only. Among the specimens received from Professor Goto, there is one lot of immature or post-larval individuals of the genus *Arhythmorhynchus* from cysts in the mesenteries of *Rana nigromaculata* from Province Musashi, collected in September, 1920. This constitutes the first record of the occurrence of post-larval individuals of this genus in any host and is at the same time the first record of the occurrence of a member of the genus in any host other than a bird. Evidence of one step in the life cycle of this species is hereby furnished. It seems highly probable that some arthropod serves as the first larval host which ingests the hard-shelled embryo surrounded by its confining membranes. From the arthropod, the larval parasite is transmitted to the frog which serves as an intermediate host intercalated between the larval and definitive hosts essential in the life cycle of all Acanthocephala. Such conditions have been pointed out previously in the developmental cycle of several other species of Acanthocephala.

The genus *Arhythmorhynchus*, parasitic as adults in migratory birds, is holarctic in its distribution though previous records have been restricted to Europe and America. There is no means of knowing what species of birds may serve as hosts in the later development of this newly discovered species. Inasmuch as the proboscis and its hooks when once formed are not subject to perceptible further growth, the essential specific characters enumerated for these post-larval specimens would hold likewise for the unknown adults of the species.

Arhythmorhynchus hispidus sp. nov.

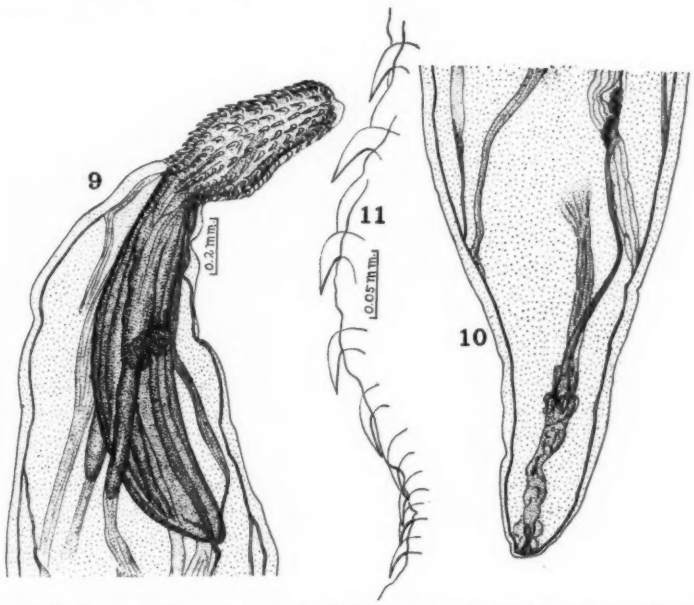
(Figs. 9–11.)

Five immature specimens have served as the basis for this description. These are 4 to 5 mm. in length and have a spindle-shaped proboscis which is 0·65 mm. long and 0·35 mm. in diameter through its thickest part. There are 20 longitudinal rows of 13 or 14 hooks each. These hooks are radially symmetrical, that is, they are not conspicuously different in size upon the dorsal and the ventral surfaces as is the case in *A. frassoni*, the type of the genus. Hooks near the tip of the proboscis are 53 to 59 μ long, the spines near the base of the proboscis are 41 μ long, while the fairly heavy hooks on the remainder of the proboscis are 47 to 53 μ in length.

The type is in the collection of the writer at Urbana, Illinois, and paratypes are deposited in the same collection and in the collection of Professor S. Goto.

Bolbosoma sp.?

Many specimens of a representative of the genus *Bolbosoma* were taken from the intestine of *Balaenoptera velifer* in the Province Rikuzen, in May, 1916. A specific determination of these specimens is deferred until a later date. For some time the writer has been accumulating a representative collection of the Acanthocephala parasitic in marine mammals. Accurate identification of any of the species within this group must await further studies based upon re-examination of the types of some of the species.



Figs. 9 and 10. The entire body of a post-larval female (type) of *Arhythmorhynchus hispidus* sp. nov. Fig. 9. The anterior region with proboscis fully extended. Fig. 10. Posterior half showing rudimentary reproductive organs.

Fig. 11. Profile showing hooks of a single row from the dorsal surface of the proboscis of *Arh. hispidus*.

Centrorhynchus sp.?

Representatives of the genus *Centrorhynchus* occur as adults in the alimentary canal of birds. Various snakes and frogs harbour the post-larval stages of the European species of this genus. In the collection which Professor Goto sent to me there are post-larval specimens of an unidentified species of *Centrorhynchus* from cysts in the intestinal wall of *Rana rugosa* from Province Musashi (collected in April, 1920); additional specimens from liver cysts of the same host from Province Ômi (collected August, 1920); and yet others from the body wall of *Rana japonica* from Province Shimôsa (taken in April, 1920).

The members of this genus are very imperfectly known. Many species have been named but no one has yet succeeded in straightening out the involved synonymy, especially of the older names. In many instances the types are not available for re-examination and the meagre descriptions of the early writers fail to provide characters sufficient for the recognition of the species with which they were dealing. Under these circumstances, it seems best to avoid further complication of the problem by omitting an attempt at identifying these immature specimens. It is to be hoped that some European investigator may undertake the revision of this genus on a thoroughly modern basis. The writer has in preparation a contribution toward a fuller knowledge of this genus from North American hosts.

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(*MS. received for publication* 24. IX. 1924.—Ed.)

EDWARD ALFRED MINCHIN

1866—1915

Separate copies may be obtained from the University Press, Cambridge

EDWARD ALFRED MINCHIN.

1866–1915.

(With Portrait-plate 30.)

By H. M. WOODCOCK, D.Sc.

Edward Alfred Minchin, M.A., F.R.S., will always be remembered as the first great British protozoologist. He may be said, indeed, to have founded the British School in this important subject and he was, during that period of his life which he devoted to it, outstandingly the leader. A special tribute to his memory, therefore, may most fittingly be paid in this Journal.

Minchin was born at Weston-super-Mare in 1866, being the younger son of Charles N. Minchin and his wife (*née* Mary J. Lugard). His early education was received mainly at the United Services College, Westward Ho! and at the Bishop Cotton School, Bangalore, where he went to join his parents at the age of 14. Owing to a physical disability from birth, he was precluded from taking part in the usual active sports of youth, with the one exception of swimming, in which he delighted. The chief recreation of his boyhood's years was the study of nature, especially of animal life, and he revelled in the rich opportunities afforded in India of following his bent. Thus were developed those powers of careful and accurate observation which were so marked a trait of Minchin's scientific work. And to the end of his life, Minchin remained an enthusiastic naturalist; although practically all his research-work was microscopical, his zoological outlook never became restricted to that of the laboratory.

It was to be expected, therefore, that when Minchin returned to England, to study at Oxford University, and gained an Exhibition at Keble College, he should select Natural Science for his Honours Course. He obtained his Degree in 1890, with 1st Class Honours in Zoology. But even before passing his Finals, Minchin had made certain original observations on one or two of the finer anatomical features of the "types" he had studied. And these notes were embodied in short papers on the skin-pouches (or stink-glands) beneath the 5th tergum of the cockroach, and on the brood-pouches in the manubrium of *Aurelia*, respectively. Shortly after taking his Degree, he was awarded the University Scholarship, tenable at Naples, and, subsequently, the Radcliffe Travelling Fellowship. With these resources he was able to visit several laboratories on the Continent. He studied at the Marine Biological Laboratories of Naples, Banyuls-sur-Mer and Roscoff; and he worked also under Bütschli at Heidelberg and under Hertwig at Munich. The subjects in which he was most interested at this period were the Sponges and the structure of

cells and protoplasm, to the latter of which he was drawn by reason of Bütschli's researches. In 1894, Minchin published the authorized English translation of Bütschli's important work on microscopic foams and protoplasm. Under Bütschli's guidance, too, Minchin first studied the Protozoa, and his first original work on the group dealt with the Gregarines parasitic in Holothurians (1893).

For several years, Minchin was Assistant to Sir Edwin Ray Lankester, and Demonstrator in Comparative Anatomy at Oxford. During this period, in a series of papers, he published the brilliant and beautiful work on Sponges, which made him recognized as one of the foremost authorities on this group. Minchin's particular contributions to our knowledge of these animals were on the origin and mode of formation of certain forms of calcareous spicule, and —even more important—on the development and larval changes in a Calcareous Sponge, *Leucosolenia variabilis*. The value of this latter work lay in the fact that Minchin was able to prove, finally, that the Sponges are a type of organization entirely distinct from the Coelenterates, as, indeed, previous work by others had already rendered probable; and that the "mesogloea," with its wandering cells, is not to be regarded as a true mesoblast, comparable with that of triploblastic animals. Personally, I am of the opinion that Minchin, in spite of the world-wide renown which he acquired later by his protozoological researches, always remained at heart faithful to his first love. Trivial things which passed in the course of conversation more than once, long after he had been appointed Professor of Protozoology, left that impression definitely on my mind; and had Minchin ever obtained the Oxford Chair, which I believe he would have preferred to any other, I think it is more than likely that he would have returned to his research on Sponges.

Minchin was elected Fellow of Merton College several years before he finally left Oxford on being appointed Jodrell Professor of Zoology and Comparative Anatomy at University College, London, where he succeeded Weldon in 1899. He held this Chair for seven years, and during his tenure of it published further work on calcareous spicules. In 1900 appeared his excellent account of the phylum in Lankester's *Treatise on Zoology*; and this work afforded him the opportunity of setting forth, clearly and concisely, the important conclusions at which he had arrived in the course of his long study. It was here that I came to know Minchin, being for two years a student in his advanced classes, and then Demonstrator and research-worker under him. As a lecturer, his subject-matter and its arrangement were admirable, if, perhaps, the manner of its delivery did not attract one to any special degree. As a teacher, he excelled in helping advanced students and research-workers, not only in encouraging and stimulating their efforts, but also by his resource in useful suggestions and in indicating important points for consideration and study. This never-failing ability and readiness to assist other workers was one of the chief characters which I would place on record, as a result of more than 15 years' association with him.

With the beginning of the century, particular attention was becoming focussed on the Protozoa, especially the parasitic forms, this being largely due to the growing appreciation of their importance in tropical diseases. And the work of Schaudinn, Siedlecki, Cuénot, Léger, Thélohan and other Continental researchers on the life-histories of members of the various groups was revealing an unsuspected complexity and specialization and opening up a most attractive field of study. This was first adequately realized, perhaps, by English zoologists when Minchin's exhaustive account of the Sporozoa, also for Lankester's *Treatise*, was published in 1903. In this comprehensive summary of knowledge up to that date, Minchin had little of his own original work to include, apart from a few observations on Gregarines (to which reference has been made above) and on a Haplosporidian (*Bertramia*). But this article at once stamped him as completely *au fait* with this important class of parasites. And I remember Minchin telling me how his interest in the Protozoa steadily increased in the course of his perusal of the already extensive literature, necessary for the compilation of this work.

Thus it was natural that, in 1905, in view of the great interest and importance attaching to the discovery of the Trypanosome of human trypanosomiasis and sleeping-sickness, Minchin should be asked to join the Commission of the Royal Society at work in Uganda, in order to study the problems associated with the transmission of the parasites by the tsetse-fly (*Glossina palpalis*) and the question of their life-history in this insect. Two years before, Minchin had married Florence Maud Fontain and his wife accompanied him on this expedition. Minchin began his part of the work by studying the anatomy of the fly and an account of its internal structure was published in the *Proceedings of the Royal Society* in that same year (1905). Minchin was an extraordinarily good technician. Both in fine dissections, such as this, and also that of the rat-flea undertaken later, as well as in all matters appertaining to technique, *e.g.*, the preparation of microscopic specimens, he worked with a care, precision and neatness which I have never seen surpassed. Unfortunately, it cannot be said that the main object of Minchin's visit to Uganda was attained. The secret of the method of transmission, and of the cyclical changes (if any) undergone by the parasites in the invertebrate host eluded all his patient efforts and was only solved by subsequent workers. But one very important item of co-related knowledge was obtained by Minchin and his collaborators, Gray and Tulloch, namely, the fact of the natural occurrence of "wild" Trypanosomes (*T. grayi*) in the fly. This discovery helped greatly to clear up the confusion previously existing owing to the manifold forms of binucleated parasites which examination of the alimentary tract had shown might be present.

Soon after his return home Minchin was appointed (1906) the first holder of the newly-established Professorship of Protozoology in the University of London, which was tenable at the Lister Institute of Preventive Medicine. Here he had ample time not only for his own research but for aiding the

efforts of the numerous advanced students and others specially interested in the Protozoa, who came from all parts to study under his guidance during the succeeding years. His first task was to work through the considerable amount of material he had brought back from Uganda, and in 1908, his account of this was published. Perhaps the most interesting point relating to morphology and biology was Minchin's discovery of the encystment of *T. grayi* in the proctodaeum of the fly. From this emerged the highly important conclusion that infection of the Vertebrate host with Trypanosome-parasites may at times occur, not by the inoculative method, but by contamination. And be it noted, as an example of the irony of fate, that almost the only point which Minchin and Thomson did not themselves ascertain regarding *T. lewisi* of the rat in its relation to the rat-flea, in spite of having the above definite instance within their own special cognizance, was that, in the case of *T. lewisi* also, the infection of the rat is by the contaminative method—*via* the faeces of the flea!

Having by this time become absorbed in the intriguing but difficult subject of the Trypanosomes, most of Minchin's subsequent research dealt with these parasites. But as a result of a visit to Rovigno, where he went with the writer in the spring of 1909, with a view to testing the accuracy of Schaudinn's work, we published conjointly certain work on Haemogregarines of fishes, and also, later, some of the results of our observations on the Haematozoa of the Little Owl. Minchin's *forte* was really cytology, or the details of cell-structure. With his brilliant technique and his *seeing* eye (I use the phrase advisedly), he was especially well qualified to interpret correctly the appearances observed under high powers of the microscope. These qualities were amply evidenced in his paper on the cytology of *T. lewisi* (1909), and in that corresponding portion of the monographic account of the life-cycle of this parasite in the rat-flea, which he was happy to see published in 1915, some months before his death. This collaboration of Minchin and Thomson was a most valuable one, because I do not think Minchin could be regarded as a great experimentalist, and the experimental work was very largely planned and almost entirely carried out by his co-worker. It cannot be questioned that the merit of this work, which will always rank as the classic study of a Trypanosome life-cycle, was enormously enhanced by the exhaustive series of experiments in connection with it. The arduous labour involved in what was chiefly Minchin's share of the work may be judged from the fact that over 1600 fleas were dissected, to say nothing of the hundreds of preparations which were scrutinized; though in this latter task, the authors had the valuable assistance of Miss Rhodes, who also did all the drawings and paintings required.

Largely *pari passu* with the earlier stages of this work, Minchin was engaged on his treatise on the Protozoa, with special reference to the parasitic forms, which was published in 1912, under the modest title of an "introduction" to their study. This book, by far the best then extant on the subject,

taken as a whole, revealed, perhaps more than any other of his works, the greatness of Minchin's mind and the comprehensiveness of his knowledge. In its philosophical treatment of the primary problems of living things, which are inevitably thrust upon our consideration in any study of the single-celled animals, Minchin's account is, in my opinion, unequalled. I make no apology for giving one illustration, in view of the extreme importance of this particular point at the present day. With masterly argument, Minchin demolished once for all the misleading and objectionable view, which had acquired a notoriety out of all proportion to the weight of evidence behind it, that the Protozoa are "non-cellular" animals; and that the Metazoan body represents, not a congeries of associated and co-ordinated unicellular units, but a single Protozoan sub-divided into "cells"—the whole animal, that is to say, corresponding phylogenetically to one Protozoan. Minchin was in a unique position to demonstrate the fallacy of this notion, because not only was he the leading Protozoologist but also an expert authority on the lowest class of multicellular animals, the Sponges. And, indeed, the whole trend of physiology and pathology to-day is to show the essential homology of the Metazoan cell with the Protozoan cell, its individual nature and its remarkable capacity for exercising independently all the basic functions of life.

Categorical reference cannot very well be made here to every piece of research which was done by Minchin; but I think his most important publications, the scope of which has been briefly outlined above, will enable those workers in other branches of Parasitology who may like to peruse them to realize his sustained diligence in the pursuit of scientific knowledge. I can say that I scarcely ever saw Minchin wasting a moment in the hours he assigned to work. His orderly and methodical nature was well exemplified by the care and thought he gave to the arrangement and classification of the enormous quantity of literature, reprints and the like, which he naturally received. The labour in connection with his index-catalogue of these papers would alone have sufficed to justify clerical assistance, the need of which he often felt. Yet I rarely heard him complain of the tediousness of this time-occupying but necessary work.

Among the honours which came to Minchin during this period were the award of the Traill Medal in 1910, and his election to the Fellowship of the Royal Society in 1911. Shortly before the world-war he was made an honorary Doctor of Philosophy of a German University; but, notwithstanding his appreciation of the valuable work of many German scientists, in the light of subsequent events, he was, naturally, disinclined to avow this particular mark of recognition, and I have found no reference to it in any of the obituary notices which I have seen. In 1914 Minchin was chosen to be President of Section D (Zoology) at the next Annual Meeting of the British Association (1915).

As his Presidential Address, he took for consideration the mode of origin and primitive constitution of living matter, giving his reasons in support of

the view that the earliest forms of life were of the nature of particles of chromatin. This admittedly speculative, but quite reasonable and likely hypothesis was developed with all his customary skill and lucidity. And it was a sad disappointment to Minchin that, when the time came, the serious condition of his health preventing him from attenting the Meeting to deliver the Address, which was read on his behalf by his friend, Mr Heron-Allen.

Apart from his scientific attainments, Minchin had an intense appreciation of literature, both classical and modern. His was a most scholarly and cultured intellect, as is, indeed, frequently indicated in his own writings. In a word, Minchin esteemed all knowledge for its own sake. He possessed also great artistic sensitiveness; he loved beautiful things and delighted in good music. In character, Minchin was a most kind-hearted man and I, like many others, know how much I owed to his friendly interest. He was gentle and unassuming; quiet in manner, but with a vein of humour. He held his views and opinions tenaciously but I would not call him dogmatic. And certainly, though, like others, he made mistakes, his views were generally proved to be sound. He died when at the height of his mental powers, at a time when it seemed as though he might reasonably expect being able to do much further valuable work for biological science; and his loss has been most severely felt by Protozoology.

The accompanying portrait is reproduced from a photograph signed and dated (14 Nov. 1910) by Minchin and presented to Prof. Nuttall.

I am very grateful to Miss Muriel Robertson for reminding me of one or two general attributes of Minchin's nature: it is difficult for any one person to envisage another adequately from all sides. I desire also to acknowledge my indebtedness for several facts and dates relating to Minchin's earlier years, which had escaped my memory, to one or other of the following Obituary notices: *Proc. Roy. Soc.* 89 B, 1917, p. xxxviii, by S. J. H.; *Journ. Path. and Bact.* 20, 1916, p. 361, by J. H. Ashworth; and *Nature*, 96, 1915, p. 148.

ON TWO SPECIES OF THE GENUS *HALARACHNE* (ACARINA; GAMASIDAE).

By G. F. FERRIS.

Stanford University, California.

(With 2 Text-figures.)

It would appear from casual references in literature that the seals and their relatives are quite commonly infested with certain mites which occur in the nasal passages or even in the bronchial tubes. Although there are several such references, apparently in but three have the mites been named. In these three cases they have been referred to the Gamasid (or Dermanyssid) genus *Halarachne*. The first species, *Halarachne halichoeri* Allman, from *Halichoerus gryphus*, an Atlantic seal, was described in 1847; the second, *H. americana* Banks, from *Monarchus tropicalis*, which is also an Atlantic species, was described in 1896; the third, *H. otariae* Steding, from *Otaria californica* (which is known to American mammalogists as *Zalophus californianus*), was described in 1923. The specimens upon which this last species was based were obtained in Germany, although the host is a native of the west coast of North America.

Specimens apparently belonging to *H. otariae*, although from a different host, have been in my possession for some time and had been recognised as apparently undescribed. In addition there have recently become available specimens representing a fourth species that is here described as new.

I acknowledge with thanks a grant from the Research Fund of Stanford University by which the cost of the blocks for the accompanying figures has been borne.

Halarachne otariae Steding.

Fig. 1 *D*, *G* and *I*.

1923. *Halarachne otariae* Steding. *Zeitschr. für Wiss. Zoologie*, CXXI. 442–493; 42 ff.; Pls. I–IV.

Previous Records. From nasal passages of the California sea-lion, *Zalophus californianus* (= *Otaria californica*), apparently a museum specimen, in Germany.

Present Record. From nasal passages of the California harbour seal, *Phoca richardi geronimensis*, Pacific Grove, California (W. P. Curtner, collector).

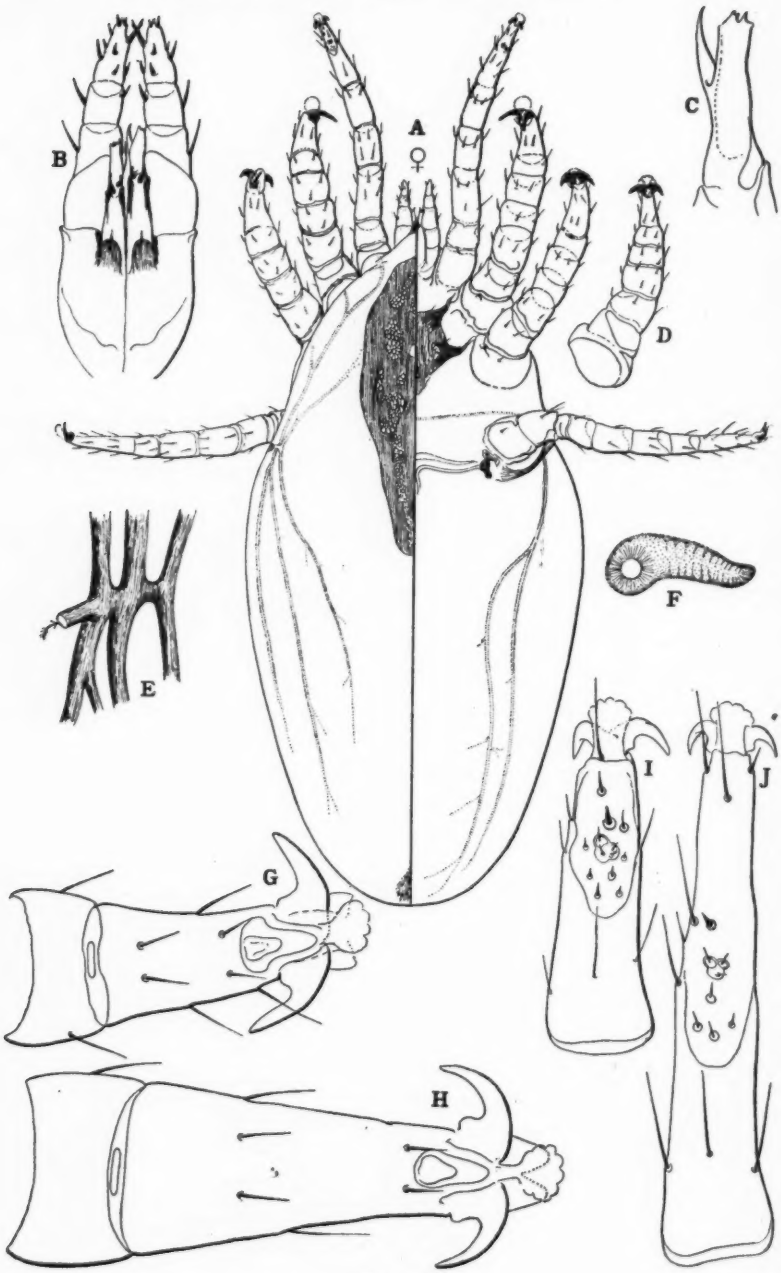

Fig. 1

NOTES. This species has been the subject of a very detailed monograph by Elisabeth Steding and it seems quite definitely recognisable, although there are some points having to do with its specific characters that are not as clear as might be desired. I feel no doubt that the specimens from the harbour seal belong to this species. The characters which separate it from the new species here described will be discussed in connection with the latter.

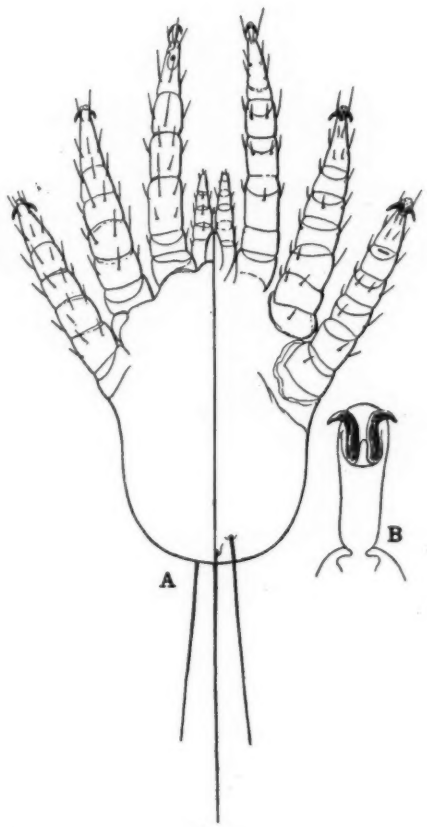

Fig. 2

LETTERING TO FIGURES.

Fig. 1. *Halarachne miroungae* n. sp. *A*, female, left half dorsal, right half ventral; *B*, ventral aspect of capitulum; *C*, chelicera; *E*, branching of the tracheae at a spiracle; *F*, spiracle; *H*, last two segments of second leg; *J*, last segment of first leg. *Halarachne otariae* Steding. *D*, third leg; *G*, last two segments of second leg; *I*, last segment of first leg.

Fig. 2. *Halarachne miroungae* n. sp. *A*, first stage nymph, left half dorsal, right half ventral; *B*, tarsal claws of first leg of same.

Halarachne miroungae n. sp.

Fig. 1 *A, B, C, E, F, H, J* and Fig. 2.

SPECIMENS EXAMINED. Several females and one first stage nymph from the nasal passages of the Guadelupe Island elephant seal, *Mirounga angustirostris*. These specimens were taken by Mr Laurence Huey, of the Museum of Natural History of San Diego, California, from the head of a seal in the Museum, which had come from Guadelupe Island off the coast of Lower California. Holotype in the personal collection of the writer; paratypes in the San Diego Museum.

Female (Fig. 1 *A*). Length 2·25 mm. Rather stout bodied, about half as wide as long. Except for the appendages the derm is entirely destitute of setae other than four on the sternal plate and three on the anal plate, these very minute. The characters of specific importance seem to lie chiefly in the form and proportions of the legs, which are relatively slender as compared with those of *H. otariae*.

In Fig. 1 *D* is shown a third leg of *H. otariae* drawn to the same scale as the corresponding leg of *H. miroungae*; although actually shorter it is also actually wider, at least on most of the segments, than the latter. In Fig. 1 *I* is shown the terminal segment of the anterior leg of *H. otariae*, to be compared with the same of *H. miroungae* in Fig. 1 *J*; in Fig. 1 *G* are the last two segments of the second leg of *H. otariae* to be compared with those of *H. miroungae* in Fig. 1 *H*, all drawn to the same scale. The third legs, which are apparently identical with the second in structure, maintain this same difference in proportions. The abrupt decrease in width of the second and third legs in *H. otariae* at the penultimate segment, as contrasted with the gradual decrease in the other species, is particularly noticeable upon a direct comparison of specimens.

In addition to these differences, *H. miroungae* shows a very definite, chitinised band which connects the spiracle with the corresponding margin of the genital slit, passing caudad of the posterior coxa. This band shows to advantage only in stained specimens. It is absent in all of the several specimens of *H. otariae* that are available and apparently constitutes a good specific difference. Structurally the two species appear in other respects to be quite the same. I find nothing in the form or areolations of the dorsal plate, the form of the sternal plate or the structure and chaetotaxy of the legs that is sensibly different.

According to Steding the abdomen of *H. halichoeri* is beset with small setae, which would immediately distinguish this species from the others. There is nothing in the original description of *H. americana* Banks that will permit the separation of this species from any of the others.

In addition to these characters of probable specific importance I am illustrating in detail others that may aid in elucidating the genus or that may

prove useful when more species are known. In Fig. 1 *B* is shown the ventral aspect of the beak; in Fig. 1 *C* the terminal segment of a chelicera; in Fig. 1 *E* the branching of the tracheal trunks at the spiracle; in Fig. 1 *F* a spiracle.

Nymph (Fig. 2). First stage nymphs of both species are at hand and seem not to differ. In Fig. 2 *A* is shown the nymph of *H. miroungae*. Spiracles are entirely lacking and the chelicerae are merely flat, pointed processes. The anterior claws (Fig. 2 *B*) are borne at the tip of a distinct stalk, the others are as in the adult.

(*MS. received for publication* 27. XI. 1924.—Ed.)

THE INFECTION OF *LUCILIA CAESAR* WITH *HERPETOMONAS*.

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The object of the enquiry reported on below was to determine, if possible, the method of infection of *Lucilia caesar*, L. with *Herpetomonas luciliae*, a common parasite of the alimentary tract of the fly, the subject being not too remote from the kalaazar problem to lack interest.

Material and Methods.

The flies were caught near Calcutta. In order to obtain clean broods, which were necessary for the work, it was found best to place wild flies upon a large covered plate of McConkey's medium and with them a wet sterilised sponge; thus a large number of eggs were laid on the medium.

As soon as possible after the eggs were laid, they were picked off the plate or sponge, some batches of them being then washed in three changes of a sterile normal saline solution and some of them not washed. The eggs were then placed on sterile meat for hatching. When the hatched-out larvae had fully developed, they were transferred from the meat-dish to a tray of sterilised sand into which they immediately burrowed. After pupation, the insects were removed to another sand-dish, this being covered by a wire-gauze cage within which the adults emerged. Clean flies having thus been obtained, we sought to determine whether they become infected through contamination of their food. For this purpose we usually allowed such flies to partake of a feed from moistened filter paper which had been soiled either (*a*) by the excreta of wild flies, or (*b*) by the gut-contents of dissected flies that had been washed on to the paper; moreover, we examined flies which had had a chance of feeding on infected material though they had not been given a set feed.

To determine if flies are hereditarily infected observations were made on infected flies' offspring brought up under as aseptic conditions as possible; and the ovaries of infected flies were dissected and examined for *Herpetomonas*. The results were negative.

The Results.

The rate of Herpetomonas infection in wild flies captured at Barrackpur and Colootolla was 75·5 per cent. (104 out of 136 flies examined).

(A) *Luciliae raised as aseptically as possible.*

All the larvae, 160 in number, showed *no Herpetomonas.*
All the adults, 110 in number, showed *no Herpetomonas.*

(B) *Luciliae raised under conditions not excluding chance infection.*

Of the larvae examined, 81 out of 107 or 75·7 per cent. harboured *Herpetomonas.*

Of the adults examined, 3 out of 90 or 3·3 per cent. harboured *Herpetomonas.* These adults may have become accidentally infected during this stage, though the possibility had been provided against as carefully as possible; on the other hand they may have remained infected whilst undergoing metamorphosis, but in this case the infection is seen to be largely lost during the change.

(C) *Infection experiments on Lucilia.*

(1) Of the adults raised from larvae as under (B) and exposed to infection in a set feed, and examined, 8 out of 38 or 21 per cent. showed *Herpetomonas.*

(2) Of the adults raised from eggs as under (A) and infected by a set feed, 33 out of 130 or 25·4 per cent. showed *Herpetomonas.*

(3) Filter paper soiled by infected flies in a glass jar on 29. vii. 1923, kept, after drying, in the same jar in the open laboratory, and moistened just before giving it to clean flies as a set feed, remained infective for

6 days: 23 flies dissected and 35 per cent. found infected.
18 „ 12 „ „ 8 „ „ „

After 33–34 days the *Herpetomonas* had apparently died for 17 dissected flies proved negative.

CONCLUSIONS.

We conclude with regard to *Herpetomonas* infection that:

1. Naturally infected flies do not infect their offspring through the ova.
2. Larvae do not become infected by being brought in contact with ova or the site where oviposition has taken place.
3. Larvae are easily infected when their food has been exposed to contamination by their parents.
4. During metamorphosis from the larval to adult stage the infection is largely if not completely lost.
5. Adults easily acquire *Herpetomonas* when exposed to infection whether or no the larval stage had been infected.
6. The parasite outside the insect becomes gradually less infective, it survives at least 18 days and dies out within 33–34 days.

We desire to thank Dr D. N. Banerjee, Demonstrator of Pathology, Carmichael Medical College, for his great assistance in dissecting a large number of the flies examined.

(*MS. received for publication* 4. XII. 1924.—Ed.)

PARASITIC AUTOTOMY OF THE HOST AS A MODE OF LIBERATION OF COELOMIC PARASITES FROM THE BODY OF THE EARTHWORM.

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The various suggestions concerning the mode of spreading of Monocystid Gregarines parasitic in earthworms have been already summarised by Minchin (1903), Hesse (1909) and more recently by Bhatia (1924). The last named author seemed to find that the spores from the vesicula seminalis may escape during copulation with the seminal fluid, may be transferred to the receptacula seminis to appear finally inside the cocoon of the earthworm. This observation has led him to suppose that the earthworm may become infected before it emerges from the cocoon. He does not, however, consider this mode of infection as the principal one, but accepts the general view that the majority of spores are set free only after the death of the worm and the complete disintegration of its body.

The presence of the few spores of Gregarines in the receptacula seminis or the cocoon of an earthworm seems to me to be completely devoid of any significance in relation to the mode of escape and spreading of the parasite. First of all the number of spores which may be found in these conditions is so insignificant that their presence cannot possibly account for the heavy infection found in earthworms and secondly, what is more important, the worm when still in the cocoon and for some time after it emerges does not seem to be susceptible to infection. That very young worms in nature are usually devoid of parasites was corroborated by the following experiment. A number of worms recently emerged from cocoons of *Allolobophora foetida* and *Helodrilus caliginosus* were kept in soil to which the ripe cysts of Gregarines were added. The latter were obtained from full grown and heavily infected specimens of worms belonging to corresponding species. The young worms were kept and carefully examined for about six weeks but in no case did the infection take place.

It seems to me, therefore, that there are two main ways by which the cysts or spores of Gregarines and the larvae of Nematodes are liberated from the body of the earthworm. The first and most important way, which accounts for the heavy soil infection and spreading of the parasites, is their liberation

after the death of the worms. This is the most natural explanation of the phenomenon we are dealing with. We know, in fact, that the ordinary soil of the fields may contain as many as 50,000 earthworms per acre; a good number of these worms die from various causes, such as partial inundation of their galleries, or wounds produced by a great variety of animals preying upon them, Arthropods, Reptiles, Birds and Mammals. The spores liberated from their decaying bodies are widely disseminated in the soil, and, in spite of being scattered over a wide area and mixed with a great bulk of soil, the chances of an individual earthworm becoming infected are very great. This is easily explained when we take into consideration the enormous quantity of soil which is passed through the intestine of an earthworm[1].

A second way of escape of coelomic parasites from the body of an earthworm, which was also mentioned by Hesse, is through the host's partial autotomy and may be observed in various species such as *Allolobophora terrestris*, *A. chlorotica* and *Helodrilus caliginosus*. This mode of dissemination equally applies both to coelomic parasites and to those living inside the vesicula seminalis.

It is well known that the cysts of Gregarines together with the larvae of Nematodes (*Pelodera pellio*) are almost invariably surrounded in vesicula seminalis by numerous layers of phagocytes which form large spherical or ovoid cysts and that subsequently the whole vesicula seminalis may in this way be broken up into a number of cysts. The brown oval-shaped phagocytic masses become free in the coelomic cavity of the genital segments and by the peristaltic movement of the worm and of its alimentary canal these cysts are gradually transferred posteriorly from one segment into the following one, passing through the apertures which are always found in the walls of the septa. They finally reach the posterior end of the body where they stop and can easily be seen on examining these segments compressed between two slides. In some specimens examined the coelomic cavity of the posterior end contained from 8 to 12 large phagocytic cysts, each showing from 45 to 190 cysts of Gregarines, in addition to a number of larvae of *Pelodera*[2]. The accumulation of these cysts produces a swelling of the posterior segments and assists partly in the compression of the blood vessels and strangulation of the corresponding portion of the intestine. A stricture appears between the distended terminal portion of the worm and the rest of the body, and it becomes gradually deeper until the parasitised segments become severed from the rest of the worm. The latter soon regenerates the lost posterior segments, while the detached portion disintegrates, liberating spores of Gregarines and larvae of Nematodes.

[1] Darwin estimated that one worm can produce 20 ozs. of castings per year and this does not represent the whole amount of the soil passed through its intestine. It has also been calculated that in the space of an acre 0·2 of an inch in thickness of earth is annually brought to the surface (Beddard, *Camb. Nat. Hist.* p. 368).

[2] A count of a number of cysts of Gregarines in separate phagocytic cysts was made from sketches drawn with the camera ludica, each cyst being compressed beneath a coverslip.

The partial autotomy of the host's body produced by parasites is known to occur also in other animals. It was described by Marenzeller (1895, quoted by Giard, 1897) in *Asterias richardi* and *Solasterias neglecta* parasitised by *Myzostoma asteriae*. Here the parasite lives in gall-like formations originating from the gastric coeca and deforming the infected arms. The latter, when the parasite is full grown, are autotomised and soon afterwards regenerated.

A phenomenon of similar nature was also observed by Giard (1897) in a Polychaete worm parasitised by Copepods belonging to the family Monstrillidae. After comparing these two cases of autotomy, Giard introduced for such a phenomenon the very convenient term of "parasitic autotomy." The observation related here on earthworms adds a third case belonging to the same category and it is probable that similar reactions by the hosts are more frequent in nature and occur in other animal groups, but that they have hitherto passed unnoticed or have been erroneously ascribed to other causes.

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(*MS. received for publication* 10. XII. 1924.—Ed.)

SUR UN CAS DE MYIASE CUTANÉE CHEZ L'HOMME.

Par ÉMILE ANDRÉ (Genève).

(Avec 3 figures dans le texte.)

En Europe, les cas de myiase cutanée humaine ne semblent pas être d'une grande rareté et la littérature en mentionne un certain nombre, mais les auteurs qui les ont publiés ont souvent négligé de donner une description détaillée des larves, de sorte qu'il est parfois difficile d'établir entre elles les comparaisons nécessaires à leur identification. Il est opportun de multiplier les dessins et les descriptions pour arriver, en les collationnant, à dégager les caractères différentiels des larves jeunes de certaines espèces d'Oestrides. C'est pour ces raisons que nous décrirons et figurerons une larve que nous avons eu récemment l'occasion d'examiner, larve qui s'était développée sous la peau derrière l'oreille, chez une jeune fille de la Haute-Savoie (France). Nous la considérons comme une larve au stade B de l'*Hypoderma bovis* (de Geer), provisoirement peut-être, car elle ne correspond pas exactement aux descriptions qui ont été données pour cette espèce par Brauer, Joly, Topsent et Condorelli. Les indications de ces auteurs diffèrent par plusieurs points, en particulier par la disposition des bandes épineuses. Mais il s'agit là, semble-t-il, d'un caractère éminemment variable, d'autant plus que Phibbs a constaté que, chez les larves au stade C, la répartition des îlots épineux peut varier d'un individu à l'autre; il est donc assez vraisemblable que cette variabilité peut exister déjà au stade B. Admettant que la disposition des bandes et des îlots épineux n'est pas constante, nous avons donc considéré la larve qui fait l'objet de ces lignes comme appartenant à l'*Hypoderma bovis* (de Geer).

Cette larve mesurait 13·5 mm. de long, sur une largeur de 3·5 mm.; elle était d'un blanc jaunâtre, un peu translucide. La disposition des épines chitineuses sur la face ventrale est représentée sur la Fig. 1. Les épines des 9 premiers segments sont relativement grosses: elles mesurent à peu près 35 μ; aussi est-il facile de discerner les champs épineux avec la loupe. Le dernier segment, le 11ème (voir Figs. 1 et 3), est partiellement revêtu d'épines beaucoup plus fines, visibles seulement au microscope, mesurant 12 à 15 μ. L'armature buccale est réduite à une petite pièce, brun-foncé (Fig. 2), analogue à celle qui a été figurée par Topsent. A l'extrémité opposée, les plaques stigmatiques sont de forme irrégulière, mais montrent nettement la disposition typique avec pores arrondis; à la plaque stigmatique fait suite une pièce chitineuse, également brun-foncé, nettement visible par transparence.

Les flancs de la larve sont lisses; nous n'y avons noté aucune indication des rangées longitudinales de tubercules latéraux.

Nous donnerons maintenant le rapport clinique, relatif à ce cas, rédigé à notre intention par le Dr Lochon, de Thonon-les-Bains (Haute-Savoie), pour lequel nous lui adressons tous nos remercîments. "La malade s'est plaint durant 2 ou 3 jours d'un petit bouton derrière l'oreille gauche avec prurit léger. Après quelques jours de pansements humides et sous la simple pression digitale, l'abcès éclata et donna passage à la larve, qui était accompagnée d'un pus séro-sanguinolent. Cette sécrétion purulente continua de couler de la plaie pendant 5 à 6 jours. L'enfant avait, le jour de l'extraction de la larve, une température de 39°·7, qui tomba d'ailleurs au fur et à mesure que l'abcès se vida. L'examen de la petite malade révéla quelques ganglions

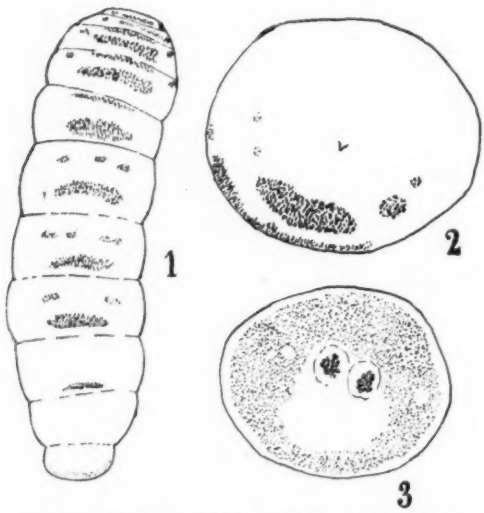

Fig. 1. Larve, vue par la face ventrale. Gross. 4 fois.
Fig. 2. Extrémité antérieure. Gross. 12 fois.
Fig. 3. Extrémité postérieure. Gross. 12 fois.

lymphatiques dans la zone infectée et un foie gros; une hémorragie nasale assez abondante se produisit le lendemain de la sortie de la larve. Les suites ont été normales et la *restitutio ad integrum* fut faite dans la semaine même."

Comme on le voit par ce rapport, il est assez vraisemblable que la larve, avant de se fixer derrière l'oreille, n'a pas cheminé à travers l'organisme de l'hôte. On peut admettre que la pénétration s'est effectuée par un follicule pileux du cuir chevelu et que, après un trajet très court, la larve a atteint le point où elle aurait continué son évolution. On sait maintenant que les larves d'*H. bovis* pénètrent chez les bovidés par la peau, qu'elles cheminent à travers l'organisme et que, après avoir passé par la paroi de l'œsophage, elles

vont se fixer dans la région lombaire, sous la peau; on sait également que l'arrivée à l'œsophage peut s'effectuer d'une façon exceptionnelle directement, par la bouche. Dans le cas qui nous occupe, la pénétration a dû se produire par la peau, mais, contrairement à ce qui se passe chez les bovidés, l'évolution s'est continuée sur place; s'il y avait eu passage par l'œsophage, la migration depuis cet organe ne se serait sans doute pas faite sans que la patiente ne ressentît quelques troubles. Dans les autres cas de myiase cutanée humaine causée par la larve d'*H. bovis* dont nous avons eu connaissance, les choses se sont passées, semble-t-il, de même façon, puisque les larves se sont développées dans les régions de la peau non recouvertes par les vêtements; si l'infestation s'était effectuée normalement, c'est à dire accompagnée de migration à travers l'organisme, il est probable que d'autres régions de la peau auraient été attaquées par ces larves. Cela ne s'applique pas, remarquons-le, aux cas de myiase cutanée humaine causée par la larve d'*H. lineatum*.

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SOME MALFORMATIONS OF THE AEDEAGUS AND CASES OF PROBABLE PARASITIC CASTRATION IN COLEOPTERA OF THE FAMILY ANOBIIDAE.

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(With 6 Text-figures.)

A large part of an account of the Anobiid beetles of the Seychelles Islands by the present writer, recently published (1924), consists of a description of a complex of species of small and obscure insects which it was extremely difficult to unravel. For these beetles, which vary in length between 1·6 and 2·6 mm., a new genus, *Nesotheca*, was erected. It was found that this genus has representatives in the Oriental Region, though the species of it which occur in the Seychelles are almost certainly endemic to those islands. Owing to the external characters being in many cases very inconstant, it proved impossible to discriminate between the various species at all satisfactorily by these characters alone, and therefore recourse was had to an examination of the genital armature, or aedeagus, of the males. This organ presents in the genus *Nesotheca* a remarkable series of quite distinct and constant forms, so that specimens which are almost, or entirely, indistinguishable externally, fall into quite clearly demarcated species when the aedeagus is used as a criterion. That the organ exhibits a quite different form in each of the ten species described can be seen by glancing at the figures in the paper to which reference has been made.

More than 50 mounts of the aedeagus in Canada Balsam were prepared, and in the course of making them five instances of malformation were brought to light. Two of these consist of forking or doubling of one of a pair of large spines, and may be classed as ordinary malformations producing asymmetry of the organ, in which there is no reason to suspect the presence of parasites; in the third case the whole apical part of the median portion of the aedeagus is malformed; while in the remaining two instances the whole organ is greatly reduced, and as larval Nematode worms are known to have been present in the body of one of the insects, it is probable that the reduction of the armature may be referred to the category of "parasitic castration."

These examples of malformation and reduction are described in some detail below, with the addition of short sections containing remarks on malformation and variation of the genital armature, and the effect of parasites thereon, in insects as a whole.

The type of aedeagus normal in Nesotheca. To explain the malformations, it is necessary first to outline briefly the general form of the aedeagus found throughout the genus. The terminology of Sharp and Muir (1912) is used[1], and the description of the aedeagus given in the present writer's systematic account of the genus *Nesotheca* is, with certain modifications, repeated here. Fig. 1 shows the organ viewed from the dorsal side in *Nesotheca typica*, the species selected as type of the genus. In all the species it is somewhat flattened dorso-ventrally, and bilaterally symmetrical, the *lateral lobes* (Fig. 1 *a*, *l.l.*) being dorso-lateral in position, and bearing more or less hairs towards the apex; the *median lobe* (Fig. 1 *a*, *m.l.*) is either subtruncate distally

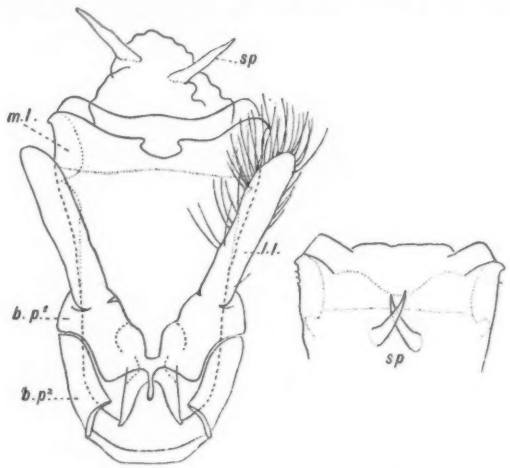

Fig. 1. Male genital armature of *Nesotheca typica*, H. Scott. *a*, aedeagus (hairs omitted on one side; lettering explained in text, pp. 177, 178) with internal sac partly everted; *b*, apex of median lobe of another example with sac retracted. Both ×ca. 113. (Reproduced by kind permission of the Editors of the *Annals and Magazine of Natural History*.)

or produced at its two distal angles into processes which are variously shaped, and sometimes hooked at the apex, in the different species; an *internal sac* is present, its surface bears many very fine hairs (indicated in Figs. 2 *a* and 3 *a* on the part of the sac visible between the "horns" of the median lobe), and it has two stout chitinous spines. The *basal piece* appears to be composed of two separate chitinous parts: (i) a distal chitinous portion (Fig. 1 *a*, *b.p.*[1]), to which the lateral lobes are articulated, and which forms a complete or nearly complete ring; dorsally this part is short, with a median distal cleft, and produced proximally in the middle into a process or spine varying in form in the several species; ventrally it is longer, and divided down the middle by a deep

[1] A terminology which, however, is by no means universally accepted: see K. Holdhaus, *L'Abeille*, xxxii, No. 2, May 1924, p. 165, footnote.

cleft, which does not, however (so far as I can determine), extend right to the proximal edge (this division is partly indicated by dotted lines in Figs. 2 and 3); (ii) a proximal chitinous piece (Fig. 1 *a*, *b.p.*[2]), forming a thickened rim on the ventral surface, and curving up at each side on to the dorsal surface, but widely interrupted in the mid-dorsal region; the remainder of the basal piece is membranous. The structure of the base of the median lobe is complex, and there is a *condyle* by which the median lobe is firmly articulated to the basal piece; attempts to separate them have not succeeded.

Judging by analogy with other cases, it may be said that, of all the structures described above, those most essential to the act of copulation are the internal sac and the pair of large spines borne by it. The sac is, partly at least, evaginated during the act, so that the spines become external, as

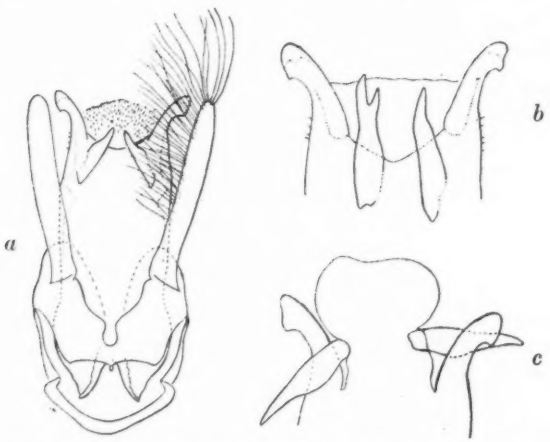

Fig. 2. Male genital armature of *Nesotheca simillima*, H. Scott. *a*, aedeagus (hairs omitted on one side), ×ca. 113; *b*, apex of median lobe of an example with left-hand spine forked, ×ca. 197; *c*, apex of median lobe with internal sac and spines exserted, ×ca. 197. (Reproduced by kind permission of the Editors of the *Annals and Magazine of Natural History*.)

shown in Figs. 1 *a* and 2 *c*. The great differences in form presented in the various species by the lateral lobes and median lobe, especially the distal angles of the latter, may be correlated to some extent with corresponding differences in the form of the female copulatory apparatus (this latter has not been examined in *Nesotheca*); but at the same time they are probably to be regarded, to a certain degree, as secondary sexual characters[1].

Forking and duplication of one of the spines on the internal sac. The two instances of this phenomenon discovered have been figured and mentioned already in the systematic paper, but the figures are repeated here to render this account more nearly complete.

[1] See remarks by Jeannel on the aedeagus in the genus *Choleva*, *L'Abeille*, XXXII, No. 1, Dec. 1923, p. 21.

Fig. 2 *a* shows the normal form of the aedeagus in *Nesotheca simillima*. Out of five examples examined, one had the left-hand spine forked at the apex (Fig. 2 *b*). No parasites were observed in the specimen from which the preparation was made.

Fig. 3 *a* shows the normal form of the organ in *Nesotheca communis*. Out of twenty-two examples examined, one had the left-hand spine completely double, right to its base. No parasites were observed in the specimen from which this malformed aedeagus was taken.

That these slight malformations have a certain importance from a systematic standpoint will be readily understood; more and more stress tends to be laid, in systematic work, on the exact form of the male genital armature, and rightly so; but the need of examining more than one specimen of a species

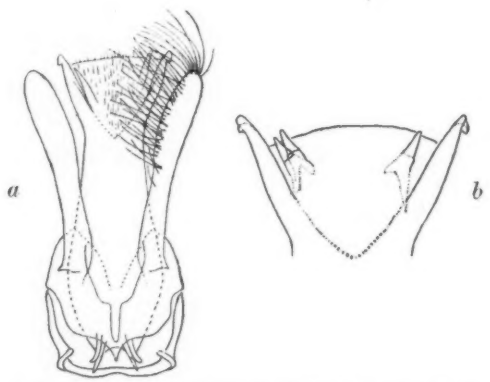

Fig. 3. Male genital armature of *Nesotheca communis*, H. Scott. *a*, aedeagus (hairs omitted on one side), ×ca. 113; *b*, apex of median lobe of an example with left-hand spine double, ×ca. 233. (Reproduced by kind permission of the Editors of the *Annals and Magazine of Natural History*.)

from this point of view is apparent; for, had the species under discussion been represented only by single examples, instead of by long series, it is possible that the aedeagus might have been described as normally bilaterally asymmetrical in respect of the spines in the internal sac, the left-hand one of which might have been described as normally forked or double—bilateral asymmetry in various parts of the aedeagus being of no uncommon occurrence in certain groups of beetles. Incidentally it may be added that *Nesotheca communis* and *N. simillima* are practically indistinguishable by external characters, but that Figs. 2 *a* and 3 *a* show how widely they differ in the form of the aedeagus.

Malformation of the apical part of the median lobe. This malformation was observed in a single case, and it is doubtful to what category the phenomenon should be relegated. Among more than twenty preparations made in

Nesotheca communis there is one example of the aedeagus with the apex of the median lobe formed as in Fig. 4. In its other parts the organ is similar to the typical form shown in Fig. 3 *a*; the points of difference lie in the apex of the median lobe, which is not produced at the distal angles into hooked horns, but into broader processes; the apical part of each process is very thin and colourless, demarcated from the pigmented part as indicated by the fine dotted lines parallel to the sides of the median lobe in the figure; the pigmented chitin on each side bears a number of minute, colourless circles, like the pits from which setae arise, though there is no trace of setae arising from them in the preparation; the spines on the internal sac look very weak and slender. There is no record of any parasites having been found in this specimen, which agrees closely with other individuals of the same species in all its external characters.

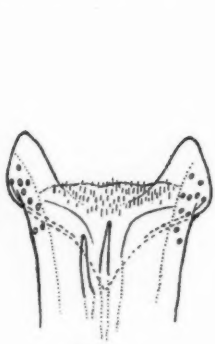

Fig. 4

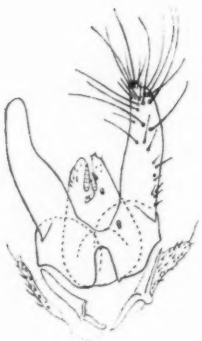

Fig. 5

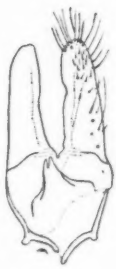

Fig. 6

Fig. 4. *Nesotheca communis*: malformed apex of median lobe, × 170.

Figs. 5 and 6. *Nesotheca communis* or *N. simillima*: two examples of the aedeagus reduced and malformed; hairs shown on the right lateral lobe only; both × ca. 113.

Reduction of the aedeagus, probably in association with the presence of Nematodes. The two specimens in which this phenomenon was found to occur are assigned to either *Nesotheca communis* or *N. simillima*. As mentioned above, these two species are indistinguishable one from the other by external characters; and since in the individuals under discussion the aedeagus is so reduced and altered as to have lost all its distinctive features, there is no means of determining to which of the two species the specimens belong. Figs. 2 *a* and 3 *a* show the normal form of the organ in these two species respectively, and Figs. 5 and 6 show the reduced and malformed examples.

The abdomen of the insect from which the aedeagus shown in Fig. 5 was taken contained a few larval NEMATODE worms. That the organ is considerably reduced in size can be seen by comparing the figure with those of the normal aedeagus (Figs. 2 *a* and 3 *a*), all the figures being to the same scale. The parts of the basal piece and lateral lobes can be distinguished, though much malformed, and also the greatly reduced median lobe. The interpre-

tation of the two pieces bearing hairs, projecting on either side of the basal piece, and apparently connected thereto by membrane, is doubtful. The small, transversely segmented bodies shown near the apex and towards the right-hand side of the median lobe are fungus spores, the presence of which is doubtless accidental. These insects probably live in fungi, some spores of which might have been in the alimentary canal, and might have got into the aedeagus during the process of boiling that organ and the surrounding parts, extracted from the abdomen, in potash, and mounting it in balsam.

The example shown in Fig. 6 is even more reduced and abnormal. The lateral lobes and part of the basal piece are distinguishable, and the median lobe may be represented by the curious portion with bifid apex lying just proximal to the point of divergence of the lateral lobes, or it may be completely atrophied. There is no record as to whether Nematodes were present or not in the insect from which this preparation was made.

In yet another species, *Nesotheca lateoblonga*, H. Scott, six preparations of the aedeagus were made, and in one of the specimens dissected the abdomen was packed with great numbers of the Nematodes, yet its aedeagus was entirely normal.

Out of all the malformations described in this paper, in only one case were Nematodes actually found in the body of the insect. Yet in the other instances it cannot be absolutely denied that they were present, since I was not looking out for them, and the possibility of their presence being connected with malformation of the aedeagus did not occur to me till a later stage in my investigations. If, however, they had been there in any numbers, it is probable that I should have seen them. As it is, the relegation of these cases of malformation to the category of parasitic castration is only presumptive; and obviously the Nematodes do not, at any rate, always cause reduction or malformation of the armature, as is proved by their presence in the specimen of *Nesotheca lateoblonga* with a normal aedeagus, which has been mentioned above. But the parasites might cause reduction or malformation in one specimen and not in another, even in the same species of insect, depending on the period of the insect's development at which they obtained access to its body, or on other circumstances. Such differences of effect, caused by one and the same species of parasite in different individuals of a single host-species, appear to be recorded in the literature, as briefly cited below.

The Nematodes themselves have unfortunately proved to be quite indeterminable. The insects containing them had been dried and gummed on cards for about 14 years before they were floated off and soaked in water to soften and relax the abdomen, which was then removed in each case prior to extraction of the aedeagus. The Nematodes, when found, were placed in alcohol: but Dr H. A. Baylis, who has kindly examined them, reports that their anatomy is so entirely indistinguishable that he cannot even state to what family they should be referred. They were extremely minute, fine but

short, not coiled; the total length of the body of the specimen of *Nesotheca lateoblonga*, from the abdomen of which very great numbers of the worms were taken, is only between 1·8 and 1·9 millimetres.

* * * * * *

No malformation whatever has been detected in any other part of the anatomy of any of the insects from which the malformed organs described above were extracted.

General remarks on malformation and variation of the genital armature. Attention has been called above (p. 179) to the importance, from a systematic standpoint, of such malformations of the aedeagus as those described in this paper. But it does not seem that malformation of the genital armature—apart from cases of parasitic castration—is at all common. The writer has asked certain of his colleagues who have studied the aedeagus in various groups of beetles, but they cannot recall having met with instances of this phenomenon[1]. A search through the literature for 13 years back[2], together with consultation of some older works, has not brought to light much that bears on the subject, but the information that has been collected may be briefly cited. A. Krausse (1915) records a malformation of the abdomen in a male example of the Melolonthine beetle *Anoxia sardoa*, Motsch.; the end of the abdomen was much misshapen and the copulatory armature pushed right out of place, but no malformation of the armature itself is mentioned. Berlese (1906) describes and discusses at some length a female example of a grasshopper, *Locusta* (= *Phasgonura*) *viridissima*, L., possessing two ovipositors, one above the other, and with certain abnormalities in the form of the terminal abdominal sclerites. Dr T. A. Chapman (1910) briefly refers to a male example of a Noctuid moth, *Acronycta tridens*, Schiff., in which the copulatory armature, instead of occupying its proper position, formed a solid mass in the interior of the abdomen; except for certain spines on the eversible membrane, or vesica, which are feebly developed, all the parts of the organ are fully formed, but poorly displayed. In none of the above cases is there any reference to the presence of parasites.

[1] Since these remarks were in print, I have seen a paper by R. Jeannel (one of whose papers has already been cited in a footnote above) entitled "La variation des pièces copulatrices chez les Coléoptères" (*C.-R. Ac. Sci. Paris*, 174, 1922, pp. 324–327); but he has apparently found no cases of malformation of the aedeagus such as are described here, not even though he has, in some widely-distributed species, made preparations of more than 100 examples of that organ. His paper deals rather with the segregation of forms into species each with a distinct, invariable, chitinous armature on the internal sac. He has not found in any group of species an orthogenetic series of variations in the form of the chitinous pieces in that sac; on the contrary, the different kinds of armature in the sac give the impression of having arisen by sudden mutations in various directions. This view would seem to give additional interest to the duplication, described above, of the spines on the sac. On the other hand, Jeannel finds that the external form of the aedeagus, like that of the whole body, furnishes fine orthogenetic series of differences in certain groups of species. His work has lain principally with certain groups of *Carabidae*, *Silphidae*, *Pselaphidae*, and *Staphylinidae*.

[2] The *Zoological Record* was worked through from 1910 to 1922, both inclusive.

The literature dealing with teratology in the Coleoptera is fairly large and very scattered. Considering its size, it is rather striking that no case of malformation of the aedeagus seems to have been recorded, even in recent years. It appears that the great majority of the recorded malformations concern the antennae, legs, and elytra, though I have compiled no actual statistics on this point. Among the works in which a number of cases are collected together, as opposed to those in which only a single instance of the phenomenon is described, may be mentioned the following: Mocquerys, *Recueil des Coléoptères anormaux* (1857–1865); Dr Bateson's *Materials for the Study of Variation* (1894); and the papers, referred to below, of Chinaglia (1910, 1911–1912) and Della Beffa (1910).

A warning not to lay too much stress, from a systematic point of view, on the form of the aedeagus in single examples of any particular species of Coleoptera, may not be out of place. This is borne out, not only by the occurrence of such malformations as those described above, but by our knowledge of the range of variation sometimes exhibited by this organ. While its form is usually remarkably constant, some wide-ranging species are known in which the aedeagus presents great differences of form in different parts of the range of the insect, though it is constant in any one district. I am indebted to Dr G. A. K. Marshall and Mr G. J. Arrow for drawing my attention to writings dealing with this matter. Curti (1913), discussing the common rose-chafer, *Cetonia aurata*, L., records great variation in the form of the aedeagus in specimens from different localities, though in any one place its build is almost constant; his figures show a remarkable series of 33 different forms of this organ taken from examples of *C. aurata* from as many (and often widely separated) parts of the Palaearctic Region. Mr Arrow (1917) has himself described and figured analogous cases in Indian Rutelinae. He states (*op. cit.*, pp. 10–12) that while the aedeagus is usually remarkably constant in form in these beetles, there are certain species in which it shows a considerable degree of variation in specimens from different parts of India, though remaining very constant in those from one and the same district; illustrations of this condition in two species appear on Pl. IV, figs. 30–32, and Pl. V, figs. 4–10, of his work. He considers that "the value of the aedeagus for the purpose of classification consists, not in any essential difference in its degree of constancy as compared with other features, but in the fact that the changes it undergoes are larger in amount, relatively to its size, and therefore more measurable, than those of any part of the external anatomy, subject as the latter is to the restraining effect of environment" (*op. cit.*, pp. 11, 12). Further instances of this kind of variability might doubtless be cited from among other Orders of insects; and it is not difficult to imagine how the still wider divergence of such geographical races, especially if accompanied by isolation due to geographical or other external causes, might lead to a condition in which pairing between individuals belonging to different races is, mechanically, an impossibility, and finally to their complete differentiation into distinct species.

Remarks on the effects of parasites on the copulatory armature in insects. No attempt is made here to review the whole subject of parasitic castration, even in the briefest outline; this section is confined to a few remarks bearing on the effect produced by parasites on the genital armature.

No reference has been found in the literature to reduction or malformation of the aedeagus in association with the presence of parasites in COLEOPTERA. Gilbert Fuchs has published (1915) a long paper on the Nematode and certain other parasites infesting the bark-beetle *Ips typographus*, L., and the weevil *Hylobius abietis*, L. He states that many young adults of the bark-beetle are killed by Nematode parasites, and that the fertility of infected females, as well as the capacity to produce a second generation of offspring in one season, are greatly reduced; but nothing is said about any effect on the male or female copulatory apparatus, or on any of the chitinous parts. Fuchs cites O. zur Strassen as recording that when large numbers of the dung-beetle *Aphodius fimetarius*, L., were examined by v. Siebold near Danzig, about three-quarters of them were found to be infected with the Nematode *Bradynema*, but that it seemed to have very little influence on their well-being or fertility.

Glaser and Wilcox (1918) have given an account of a *Mermis* epidemic amongst grasshoppers (*Melanoplus atlanis*, Riley, and *M. bivittatus*, Say; fam. ACRIDIIDAE) in the United States, but it is not mentioned that the parasite has any effect on the form of its hosts, except that when a grasshopper contains a number of the *Mermis* its abdomen is considerably swollen.

Parasitism of ants by *Mermis* is well known. Gigantic forms of worker, possessing ocelli, and known as "mermithergates," occur in a number of genera (see Wheeler, 1910, p. 420). Crawley and Baylis (1921) describe "mermithogynes," female ants with reduced wings and distended abdomens due to the presence of *Mermis*, in the genus *Lasius*. But I am not aware that mention has been made of any effect of the parasites on the copulatory apparatus in either sex, or, indeed, that male ants parasitised by *Mermis* have been discovered at all. Likewise in the case of humble-bees infested with the Nematode *Sphaerularia*, it is, at least according to certain text-books, only the queen-bees which are parasitised.

Turning, however, to other kinds of parasites, it is possible to cite several records of reduction and modification of the copulatory apparatus of the host. J. Pérez (1886, p. 33) in discussing the effects of stylopization of *Andrena*, remarked that in some cases the sting of the female bee is reduced in size, while the male copulatory armature is diminished in length, breadth, and curvature, a statement repeated by Dwight Pierce (1909, p. 34). The last-named author, however, enumerates instances of heavily stylopized males and females being taken *in coitu*, showing that stylopization by no means always prevents pairing. Geoffrey Smith and Hamm (1914, p. 448) were unable to find any reduction or abnormality of the male armature or female ovipositor in a long series of stylopized specimens of the species of *Andrena* which they studied.

In the Order Homoptera, Giard (to whom, I believe, the introduction of the term "castration parasitaire," and at any rate a great elaboration of the subject, is due) has studied the effects of a Hymenopterous parasite (*Aphelopus*) and a Dipterous parasite (*Ateleneura*) on certain leaf-hoppers of the genus *Typhlocyba*. He records (1889) that in two species of *Typhlocyba* the *Aphelopus* causes great reduction of the ovipositor, while *Ateleneura* seems to have much less influence on the development of this organ. On the male armature of one host-species both *Aphelopus* and *Ateleneura* seem to produce only very slight modifications; but in the other species of *Typhlocyba* which he studied, males infested with *Ateleneura*, and above all those parasitised by *Aphelopus*, have the parts of the armature greatly reduced, and the specific characters profoundly modified. Dwight Pierce (1909, p. 34) quotes Prof. E. D. Ball as stating that stylopized leaf-hoppers can hardly be determined on account of changes in the form of the genitalia.

R. de la Vaulx has recently written a short general article (1922) on parasitic castration in Arthropods, but it contains no allusion to modification of the copulatory armature. He remarks, however, that presence of a parasite may profoundly modify the secondary sexual characters while leaving the gonads quite normal, or, *vice versâ*, may cause complete abortion of the gonads and consequent sterility without any alteration of the external characters.

* * * * * *

I desire to express my indebtedness to the Editors of the *Annals and Magazine of Natural History* for the loan of the blocks from which Figs. 1–3 are printed; to Dr H. A. Baylis, for examining the Nematodes; and to Dr D. Keilin for kind help and advice.

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(*MS. received for publication*, 19. XI. 1924.—Ed.)

NOTE ON THE OCCURRENCE OF A MERMITHID WORM IN THE BODY OF A TERMITE, *CORNITERMES ORTHOCEPHALUS*, SILVESTRI.

By W. RUTTLEDGE, B.A.

Sidney Sussex College, Cambridge.

(*From the Museum of Zoology, Cambridge.*)

(With 2 Text-figures.)

Some soldiers and workers of *Cornitermes orthocephalus*, Silv., were taken at Campos, State of Rio de Janeiro, Brazil, in July 1923 by Mr F. Balfour Browne, the leader of a party of Cambridge entomologists which visited South America at that time. One of the worker termites was subsequently found to contain a parasitic worm in its abdomen.

The termites were determined by Prof. F. Silvestri as *Cornitermes orthocephalus*, Silv., var. *superior*, var. nov.[1] The parasitic worm was submitted to Dr H. A. Baylis, who reported that he could only refer it to the genus *Mermis*, but was unable to determine it specifically, owing to its characters being purely larval. Dr Baylis stated that, as is well known, the worms of this group do not become sexually mature until some time after their emergence from their insect hosts; while still living as parasites in the bodies of the latter, or at the time of emergence, although the worms may be of almost full size, their characters are larval, and it is consequently not possible to determine the various forms in the present state of our knowledge of the comparative morphology of the larval stages. The specimen at present under discussion was left in Dr Baylis' keeping at the British Museum.

The parasite was clearly visible through the dorsal body-wall of the termite, and was partly coiled on itself. The host-insect did not appear to differ in any way from the unparasitised individuals of the same species; its abdomen as shown in Fig. 1 is distorted owing to the body-wall having been accidentally torn.

The only previous record of a Mermithid worm parasitising a termite that I have been able to find is cited by E. Hegh in his work *Les Termites: partie générale* (Brussels, Sept. 1922). In the section (p. 598) on the various kinds of

[1] [Cotypes of this new variety are in the Cambridge University Museum of Zoology. The determination was received from Prof. Silvestri on a postcard dated 3. iv. 1924. Mr Ruttledge is now (xi. 1924) in the Sudan, and at the time of checking his manuscript for publication I am unaware whether Prof. Silvestri's description of the var. *superior* has yet been published. Both *Cornitermes* and the other genus mentioned in this note, namely *Thoracotermes*, belong to the family Metatermitidae of Holmgren's classification.—Hugh Scott.]

Nematodes known to parasitise termites there is a reference to a *Mermis*, which could not be determined more exactly, having been found by Prof. Silvestri in the abdominal cavity of a soldier of *Thoracotermes brevinotus*, Silv., collected near Mamou in French West Africa. In this case also, the infested termite showed no difference in form or size from uninfested individuals.

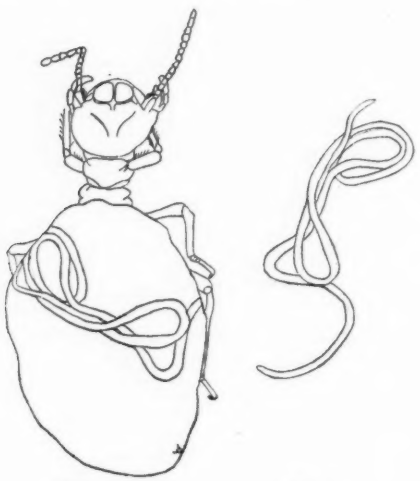


Fig. 1. Fig. 2.

Fig. 1. *Cornitermes orthocephalus*, Silv., worker, with the *Mermis in situ*; ×8.
Fig. 2. Outline of the *Mermis* removed from its host; ×8.

(*MS. received for publication* 21. XI. 24.—Ed.)

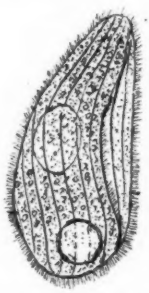
ON A NEW CILIATE, *BALANTIDIUM KNOWLESII*, SP. NOV., A COELOMIC PARASITE IN *CULICOIDES PEREGRINUS*.

By EKENDRANATH GHOSH, M.Sc., M.D.
Professor of Biology, Medical College, Calcutta.

(With 1 Text-figure.)

The parasite herein described was found in the coelomic cavity of *Culicoides peregrinus* by Mr A. R. O. Smith, of the Calcutta School of Tropical Medicine and Hygiene, and was brought to me for identification. It is named after the Teacher of Protozoology, Calcutta School of Tropical Medicine. Numerous specimens with several undergoing ordinary transverse fission were observed.

Diagnosis. Body broadly ovate, wider posteriorly than anteriorly, slightly less than twice as long as wide. Anterior end narrow and tapering. Posterior end rounded. Dorsal surface convex, more prominent posteriorly and with several faint longitudinal grooves. Ventral surface flattened. Peristome large,



Balantidium knowlesii n. sp. ×1050

cuplike, ovate in shape and occupying the ventral surface leaving a narrow space all round except on the right lateral margin. Adoral row of cilia not well developed. No distinct undulating membrane. Body completely ciliated. Anterior body-cilia long. Ectoplasm thin. Endoplasm coarsely granular. Macronucleus rounded or broadly oval, and placed in the middle of the body. Micronucleus single, lodged in a depression on the macronucleus. Length 0·04 mm. Greatest width 0·025 mm.

The present species differs from all the known species of *Balantidium* and agrees with *B. rotundum* Bezzen., in having a large wide peristome. But it differs from *B. rotundum* Bezzen. in shape, in having a large oval peristome occupying nearly the entire ventral surface, a round macronucleus placed in the middle of the body and the contractile vacuole at the posterior end.

(*MS. received for publication* 7. I. 1925.—Ed.)

ON THE OCCURRENCE OF *PIROPLASMA* (*BABESIA*) *CANIS* IN MALAYA.

By A. NEAVE KINGSBURY, M.B., B.S., B.Sc. (Lond.), D.P.H., D.T.M. & H.

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Piroplasma canis is known to have a wide distribution in Asia. It has been recorded in India by Dalgetty (1904), Christophers (1907) and others, in French Indo-China, by Mathis (1909), in provinces of China, Shan-tung, by Eggebracht (1908), and Kiang-su by Fischer and Scheidemann (1920). Japanese workers have also found infected dogs in Japan. Recently Witkamp has suggested that *P. canis* might be the cause of the canine jaundice in the Dutch Indies, which has been described by Van Lier. Endemic centres are thus present in countries to the east and west of Malaya, and the islands to the south are suspect on clinical grounds, but the occurrence of *P. canis* in this country does not appear to have been hitherto recorded.

Chronic canine piroplasmosis, characterised by debility, anaemia, and occasional rises in temperature, is the usual form of the disease met with in the east. It is not surprising that these chronic cases are sometimes overlooked, because the examination of blood films is frequently negative, and urobilinuria is but transient in such infections, while the numerous helminths found in dogs in the tropics appear to account sufficiently for the wasted and anaemic condition of the animals.

Early in March 1924, Mr T. W. W. Wright, Veterinary Surgeon to the Penang Municipality, submitted blood films to the writer from a Penang bred dog, which was emaciated, anaemic and had occasional rises in temperature. In Leishman-stained films a number of red corpuscles were found to contain pear-shaped and other bodies which on morphological grounds were considered to be *P. canis*. About 1 in 200 red corpuscles were infected and pyriform, amoebic and dividing forms, were seen[1]. A count of the parasites gave the following result:

Intracellular *pyriform* bodies:		Intracellular *round or amoeboid* bodies:	
One per corpuscle (P)	6 %	One per corpuscle (O)	22 %
Two per corpuscle (PP) ...	46 %	Two per corpuscle (OO) ...	7 %
Four per corpuscle (PPPP) ...	8 %	Dividing form (D)	3 %
		Extracellular forms	8 %

Nuttall and Hadwen (1909) have shown that in acute infections the percentages of PPPP, OO, and D forms are unusually high, and the subacute type of infection indicated by the parasite count in this instance agreed with the clinical course.

[1] It has not been deemed necessary to reproduce the diagrammatic figures of the parasites sent with this paper; they are typical and correspond to those repeatedly figured (see for instance *Parasitology*, VI. 304).—Ed.

A few days later another dog was noticed by Mr Wright to be emaciated and anaemic, and in the absence of intestinal parasites it was thought that it might be a second case of piroplasmosis. Several blood films were examined with negative results, though a few nucleated red corpuscles and some polychromatophilia were noted. At my request Mr Wright inoculated a young puppy subcutaneously with a few cubic centimetres of blood from this second dog (March 7th) and daily blood examinations were made on the puppy. Three days after inoculation, there was a transient rise in temperature, but no parasites were found until April 19th, when a few infected corpuscles were seen. The number of parasites increased slightly day by day until April 26th, when about one red corpuscle in ten thousand contained *P. canis*, but after this date all examinations were negative. The puppy became slightly anaemic but not emaciated.

The local Vector.

The invertebrate host of *P. canis* in S. Africa was shown by Lounsbury to be *Haemaphysalis leachi*, but Christophers demonstrated that *Rhipicephalus sanguineus* is the vector in Madras. Brumpt (1919) incriminated *Dermacentor reticulatus* as the carrier in S. Europe. Fischer and Scheidemann (1920) asserted that the invertebrate host in Kiang-si, China, is *R. evertsi*[1], though the dogs on which they made their observations were also infested with *R. sanguineus*.

Some fourteen years ago Dr A. T. Stanton forwarded a collection of ticks from Malaya to Prof. Nuttall, who kindly identified the specimens obtained from dogs as *R. sanguineus*. The writer has lately examined ticks from ten dogs in Kuala Lumpur and *R. sanguineus* was found on nine of them.

The local vector is therefore probably *R. sanguineus*.

My thanks are due to Mr J. E. Lesslar for making daily blood examination of the inoculated puppy during my absence from the laboratory in April 1924.

[1] *R. evertsi* is a purely African species and has never been recorded from Asia. The authors cited no doubt made an error in their determination.—ED.

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(*MS. received for publication* 12. I. 1925.—Ed.)

THE NEMATODE GENUS *RAILLIETOSTRONGYLUS.*

By CLAYTON LANE.

The genus *Raillietostrongylus* Lane, 1923, was essentially characterized by the presence of "rudimentary subventral semilunes" guarding its oral aperture. In its type and only species *R. samoensis* Lane, 1923, these structures were described as "most rudimentary." Cameron (1924) states bluntly that cutting plates do not exist in this species, so that he can see no reason for removing it from the genus *Globocephalus*. The natural implication of the wording is that in designating the new genus a seriously inaccurate observation was recorded.

The facts are these. In both the publications involved there have been described and drawn certain structures which occupy the position, and have the general contour, of the subventral semilunes of *Necator*; their inner margins unite ventrally, as in *Necator*, in a ventral notch which, as in *Necator*, is visible through the cuticle bordering the oral aperture. Moreover both publications agree in referring these structures to the oral capsule; Cameron explaining them as due to the contour of the top of the capsule, a description which, being held equally applicable to the semilunes of *Necator*, is accepted.

On these agreed facts the writer inferred these structures to be rudimentary homologues of the well-known subventral semilunes of *Necator*, and to be necessarily of taxonomic importance. Cameron, while granting that the chitinoid gives the appearance of small cutting plates objects to their being described as such since "the edges of the notch do not project at all"—an ambiguous expression.

There is then agreement (1) that cutting plates do not exist, the original description having scrupulously avoided the term and Cameron having denied their presence; (2) that structures actually exist in the position and with the contours of the semilunes of *Necator*, structures which Lane finds sometimes uncovered by the edge of the oral aperture and holds to be rudimentary homologues of the semilunes of *Necator*, an inference with which Cameron does not agree because they do not project.

It is therefore clear that the disagreement indicated is one of inference and not of fact, a vital difference where reputations for accurate observation are involved. It will be settled by those observations and inferences of independent helminthologists, which will certainly be made in the future.

It is matter for personal regret that the unfortunate omission explicitly to differentiate observation and inference in the original communication should

seemingly have misled a younger helminthologist; and that in his discussion on the synonymy the latter should not have intimated how much of his reasoning and conclusions are to be found in the earlier publication.

Finally, it cannot be admitted that designation of type specimens is a matter which, although this is desirable, actually requires published intimation by the originator of a specific name, or which, in the absence of such publication should, or can, be subsequently undertaken by another, irrespective of the actual specimens on which the species was instituted by its author, and without reference to him.

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(*MS. received for publication* 21. I. 1925.—Ed.)

A REVISION OF THE BRITISH SPECIES OF *CLAVELLA* (CRUSTACEA, COPEPODA), WITH A DIAGNOSIS OF NEW SPECIES: *C. DEVASTATRIX* AND *C. INVICTA*.

By W. HAROLD LEIGH-SHARPE, M.Sc. (Lond.).

(With 4 Text-figures.)

The genus *Clavella* Oken, 1815, comprises parasitic Copepods belonging to the family Lernaeopodidae. The object of this paper is to dwell upon the following characteristics of the genus:

Members of the genus *Clavella* are pre-eminently parasitic on Gadoid fishes. (Four British species not occurring on Gadoids have already been removed to other genera; one doubtful species will probably have to follow, and I am suggesting the removal of two more.)

Each species of *Gadus* is accompanied by characteristic species of *Clavella*. Where two or more species of the latter occur in the same host, each has a definite location, thus with

Gadus morrhua { *C. sciatherica* occurs in the buccal cavity, pharynx.
C. iadda occurs on the skin, fins, tail, anus.

Gadus aeglefinus { *C. dubia* occurs on the gill filaments.
C. brevicollis occurs on the body, anal fin.

One of the most decisive characters serving for identification is the *bulla* (Fig. 1). This varies, according to the species, (*a*) in shape, being spherical, ovate, clavate, or otherwise, and (*b*) in respect to its channellings. There are two channels corresponding to the two maxillae:

In *C. iadda*[1] each channel divides into **4**.

In *C. sciatherica* the two channels unite to form a single channel which afterwards forks, each branch dividing into **3**.

In *C. dubia*[1] each channel divides dichotomously, terminating in **8**.

In *C. devastatrix* each channel divides into **4**.

Description of the Genus *Clavella*.

Females. *Cephalothorax* distinctly separated from the trunk, long, vermiform, slender, bent posteriorly to the body axis, often in line with second maxillae, and unprovided with a dorsal carapace. Neither abdominal appen-

[1] Only the channel on one side appears in the figure.

dages or anal laminae present. Abdomen reduced to an unpaired genital process ventral to the anus. *First antennae*, three-jointed. *Second antennae* uniramose, turned inwards towards each other across the frontal margin of the head and often meeting and even overlapping in the middle line. *First maxillae*, bipartite with a palp. *Second maxillae*, entirely fused, very short. *Maxillipedes*, stout with terminal claw, usually with an accessory claw on the inner margin.

Males. *Cephalothorax* and trunk fused and folded together ventrally into an unsegmented Cyprian ovoid, without distinction of parts. No dorsal carapace or abdominal appendages. *First antennae*, two-jointed. *Second antennae* uniramose and three-jointed. *First maxillae* bipartite without a palp. *Second maxillae* and *maxillipedes* large, similar, close to the mouth cone and strongly clawed. All the appendages point diagonally and forwards. Between the maxillipedes in the median line a short, rounded mediative process, homologous with the paired structure similarly situated in the males of *Lernaeopoda*.

C. uncinata Müller.

I have great doubts as to the existence of this species because: (1) I have never yet examined a *Clavella* which exhibited a combination of all the characters cited by any one author. (2) The extraordinary discrepancies in the descriptions of various authors (cf. Scott and Scott, 1912, and Wilson, 1915). (3) The multiplicity of hosts on which this species is alleged to be found. Thus, while Scott and Scott favour *Gadus merlangus*, adding "and others," Wilson found the majority of his specimens on *G. morrhua* (on the gills mainly, but also on mouth and fins) and some on *G. macrocephalus* and *Pollachium carbonarium*.

I hold that former investigators have confounded the species separated by me as *C. iadda*, *C. sciatherica* and *C. devastatrix* and possibly others; which of these was Müller's original *C. uncinata* it is impossible to say.

C. sciatherica Leigh-Sharpe.

Literature: Leigh-Sharpe, 1918 and 1920.
Host: *Gadus morrhua*, in buccal cavity, pharynx, gill arches, not on gill filaments.
Locality: Plymouth, Lowestoft.

Cephalothorax plainly longer ($1\frac{1}{4}$–$1\frac{1}{2}$ times) than trunk, very slightly widened up to head. Base of neck enlarged and bulbous. Trunk globose, not flattened, slightly longer than wide. Second maxillae short, with a discoid termination; not in line with the cephalothorax. Bulla spherical (see Fig. 1). Genital process elongate, of medium size. Ovisacs not tapering, with 8–10 rows of approximately 20 ova per row.

Males with dorsum boldly arched, but bulging posteriorly. Rostrum minute. Mouth cone long. Mediative process posteriorly situated.

C. iadda Leigh-Sharpe.

Literature: Leigh-Sharpe, 1920 and 1924.
Host: *Gadus morrhua*, on fins, tail, round anus.
Locality: Lowestoft, Iceland.

Cephalothorax but little longer ($1\frac{1}{4}$ at most) than trunk; dorsi-ventral curve slight. Head not enlarged. Base of neck separated from trunk by a slight constriction; base not bulbous nor differentiated. Trunk subquadrate, flattened,

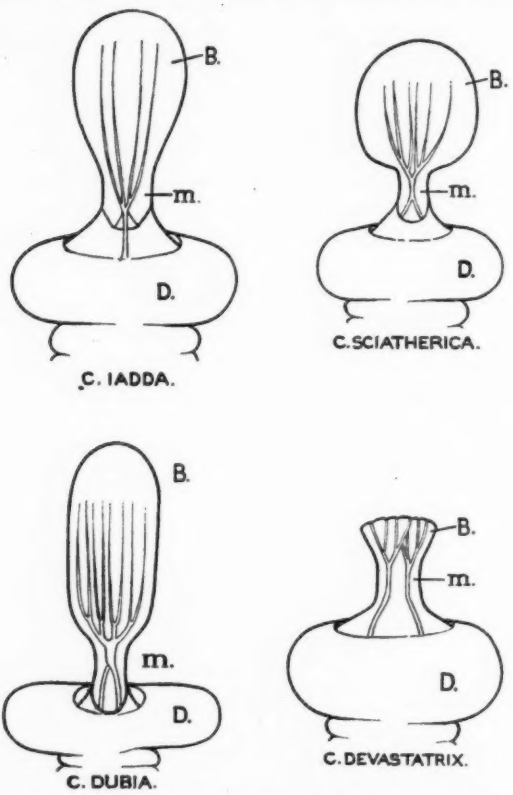

Fig. 1. A comparison of the bulla of the common species of *Clavella*. B. bulla; m. manubrium; D. disc.

slightly longer than broad. Second maxillae short with a slightly widened discoid termination, in line with the cephalothorax or at least the central third of the latter. Bulla ovate, somewhat cylindrical (see Fig. 1). Genital process of medium size, elongate, trilobed. Ovisacs $1\frac{1}{3}$–$1\frac{1}{2}$ times as long as trunk, about the length of the cephalothorax, not slender, but tapering, with apparently 28 ova in a row.

Males with a flatter form of carapace than in *C. sciatherica*.

C. devastatrix sp. nov.

Host: *Gadus merlangus.*
Locality: Plymouth.

Cephalothorax longer (about $1\frac{1}{4}$) than trunk, dorsi-ventral curve great. Head not enlarged. Base of neck bulbous and very much enlarged. Trunk globose, slightly longer than broad resembling *C. sciatherica.* Second maxillae not short, with a slightly widened discoid termination, not in line with cephalothorax, but almost perpendicular to it. Bulla truncated, but I fear the whole bulla is not present in all specimens I have examined (see Fig. 1). Genital

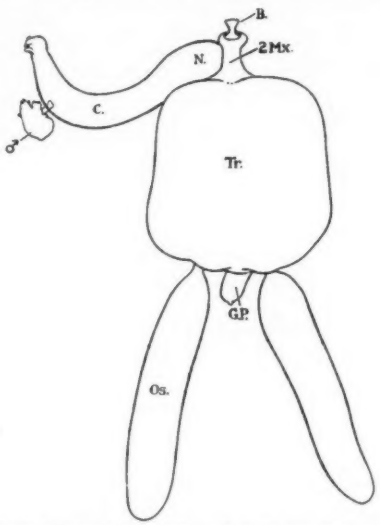

Fig. 2. *Clavella devastatrix* ♀, bearing one ♂. C. cephalothorax; N. neck; B. bulla; 2Mx. second maxillae; Tr. trunk; G.P. genital process; Os. ovisacs.

process elongate and of medium size; lateral lobes as in *C. sciatherica.* Ovisacs $1\frac{1}{3}$ times as long as the trunk, not tapering, approximately 35 ova in a row.

Males very small, greatest length about 0·15 mm. (see Fig. 4); the carapace, though shrivelled, is more elevated and conical than in most species.

C. invicta sp. nov.

Host: *Gadus pollachius.*
Locality: Plymouth.

Cephalothorax very much longer ($1\frac{3}{4}$ times) than the trunk, not greatly curved. Head not enlarged. Base of neck bulbous and much enlarged. Trunk globose, $1\frac{1}{4}$ times longer than broad. Second maxillae not short (termination damaged). Bulla (torn off in all specimens sent to me). Genital process small, trilobed, lateral lobes large. Ovisacs short, thick, and very tapering, $\frac{3}{4}$ length of trunk, widely separated from one another.

Males unknown.

C. dubia T. and A. Scott.

Literature: Scott and Scott, 1900 and 1912; Leigh-Sharpe, 1924.
Host: *Gadus aeglefinus*, on gill filaments.
Locality: Iceland, North Sea (Scott).

Cephalothorax not so long as trunk. Head not enlarged. Base of neck not differentiated. Trunk stout, ellipsoid. Mandibles stout, somewhat expanded near the middle, with four large teeth and two or three smaller ones. First maxillae bipartite, moderately elongated, provided with two narrow terminal lobes ending in tolerably long spines. Second maxillae extremely short. Bulla clavate (Fig. 1). Genital process robust. Ovisacs longer than trunk.

Males with front of rounded dorsum flattened, rostrum long and pronounced (Leigh-Sharpe, 1924).

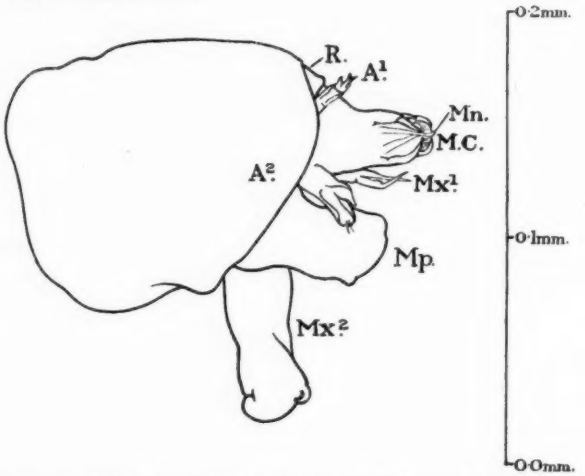

Fig. 3. *Clavella devastatrix* ♂. A¹. Antennula; A². Antenna; M.C. mouth cone; Mx¹. first maxillae; Mx². second maxillae; Mp. maxillipede; Mn. mandible; R. rostrum.

C. brevicollis M. Edwards[1].

Literature: Scott and Scott, 1912.
Host: *Gadus aeglefinus*, on anal fin, body, not gills.
Locality: Firth of Forth.

Cephalothorax shorter than trunk, very broad and inflated, half as wide as trunk, and in same straight line with it. Head not enlarged. Base of neck not differentiated. Trunk stout, subglobular, rather longer than broad. Mandibles slender, a few large teeth with smaller intermediate ones. First maxillae moderately stout, provided with two subapical processes bearing short terminal spines and two minute lateral spines on the same side as the processes. Second maxillae short, stout. Bulla spherical. Genital process small, distinct.

Males unknown.

[1] I have not met with this species.

C. stellata (Krøyer)[1].

Literature: Scott and Scott, 1912.
Host: *Merluccius vulgaris*, scales of body.
Locality: Firth of Clyde.

Cephalothorax elongated, slender, longer than trunk and in same straight line with it. Head not enlarged. Base of neck not differentiated. Trunk almost a perfect ellipsoid, junction with cephalothorax a narrow isthmus. Appendages said to resemble those of *C. uncinata* (!). Second maxillae moderately long, said to be observably separate but surrounded by a common cuticle (I presume this means that they are fused as in other species). Bulla a thin dark horn-coloured disc on a short manubrium; the disc ornamented all round

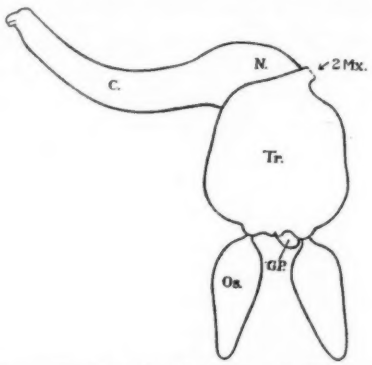

Fig. 4. *Clavella invicta*, lettering as in Fig. 2.

with pellucid oval markings arranged at nearly equal intervals in the manner of radii which do not extend quite to the circumference. Genital process rudimentary.

Males unknown.

The following British species, formerly included in the genus *Clavella*, have, for various, reasons been transferred to other genera, chiefly on account of the characters of the male. It should be noted that none of the species so transferred are parasitic on Gadoid fishes.

Species	Host	Transferred to genus:
C. rugosa (Krøyer)	*Anarrhichas lupus*	*Clavellodes* Wilson, 1915
C. marginata (Krøyer)	*Clupea alosa* *Clupea finta*	*Clavellisa* Wilson, 1915
C. scombri (Kurz)	*Scomber scombrus*	*Clavellisa* Wilson, 1915
C. paradoxa van Beneden	*Scomber scombrus*	*Clavellopsis* Wilson, 1915

The species *C. quadrata* Bassett-Smith from *Callionymus lyra*, at Plymouth, which I have not met with, will probably have to be transferred also, because:

[1] I have not met with this species.

(1) It is not parasitic on Gadoid fishes. (2) It was poorly described from a few specimens. (3) The males have not been found and in their absence it is impossible to say in which of the allied genera it should be placed.

Genus *Alella* gen. nov.

I have erected this genus for the inclusion of two British species (and some not British) formerly included in the genus *Clavella*, namely *C. canthari* (Heller, 1865) and *C. alata* Brian, 1906, for the following reasons: They are not parasitic on Gadoid fishes; *A. canthari* occurs on *Cantharus lineatus* and *Pagellus centrodontus* whilst *A. alata* occurs on *Phycis blennoides*. In *Alella* the second maxillae are not completely fused but are either (*a*) fused only at their distal half as in *A. alata* or (*b*) entirely separate and reduced to two small lobes ("entirely lacking" according to Wilson, but I claim he is obviously mistaken, *vide* Scott and Scott) as in *A. canthari*. The bases of the second maxillae bear on their outer sides, at their junction with the cephalothorax, spherical extensions variously described as horn-like, gibbous or wing-like. The males of the two above-mentioned species differ slightly from those of *Clavella* and strongly resemble one another in the galeate posterior projection of the dorsum and the character of the second maxillae.

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A REVISION OF THE LUNG-WORMS OF CETACEA.

By H. A. BAYLIS, M.A., D.Sc., and R. DAUBNEY, M.Sc., M.R.C.V.S.

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(With 25 Text-figures.)

Great confusion prevails in literature with regard to the various species of nematode worms inhabiting the air-passages and blood-vessels of whales, porpoises and dolphins. These worms form a group analogous, and, as we believe, very closely related to the genera *Metastrongylus*, *Dictyocaulus*, *Synthetocaulus*, and *Haemostrongylus*, which occur in similar situations in terrestrial mammals. The genera named are referred to the family Metastrongylidae Leiper (1908), as restricted by the exclusion of the forms now included in the family Trichostrongylidae Leiper (1912). The forms found in Cetacea, of which the typical genus is *Pseudalius*, have been ranked first as a subfamily Pseudaliinae of "Strongylidae" by Railliet and Henry (1909) and later as a family Pseudaliidae of Strongyloidea by Railliet (1916).

As the result of a study of a number of species of this group we are of the opinion that there is no justification for the erection of a separate family to contain them. Indeed, it is extremely doubtful whether sufficient group characters can be found to separate them at all from the Metastrongyles of land mammals. We therefore propose to treat them as members of the family Metastrongylidae.

The rays of the bursa are greatly reduced in the four genera mentioned above, although all the rays typically present in the bursa of a Strongyle are still recognisable. In the forms from Cetacea the rays tend to be still further reduced, the externo-dorsal rays being absent, while the ventral rays are single instead of double. The lateral rays show more or less clear indications of a trilobate termination, representing the three rays of this system, two of which are frequently fused for the greater part of their length in the terrestrial forms. In certain cases the dorsal ray is reduced almost to the point of disappearance, but its two papillary terminations are almost always apparent. In one of the genera (*Stenurus*) there is a moderately well-developed buccal capsule, but in the remaining forms the capsule is as much reduced as in the better-known members of this family.

The typical arrangement of the cephalic papillae appears to be two circles of six papillae each, the papillae of the anterior circle being somewhat smaller than those of the posterior circle. One pair in each circle is lateral, the others

submedian. The papillae appear to be best developed in the genus *Stenurus*. In the other genera they are less apparent.

A remarkable feature which all the species we have examined have in common is that cuticular striations appear to be absent.

Throughout the group the vulva is situated close to the anus, and the arrangement of the female genital organs is similar in all the species. There is a short vagina, usually surrounded by a well-developed sphincter muscle near its junction with the uterus. The common trunk of the uterus is relatively short, and forms a reservoir for embryos, giving off anteriorly two wide, parallel branches.

The embryos resemble those of the better-known Metastrongylidae in that the oesophagus is a simple tube. There is no mouth-opening, at least in the embryo of *Pseudalius inflexus* (Fig. 6). In this species there is a minute cephalic button, and the obliquely truncate tail is very similar to that of *Synthetocaulus* embryos.

With one exception all the known members of this group are parasitic in Cetacea, one species occurring in a seal.

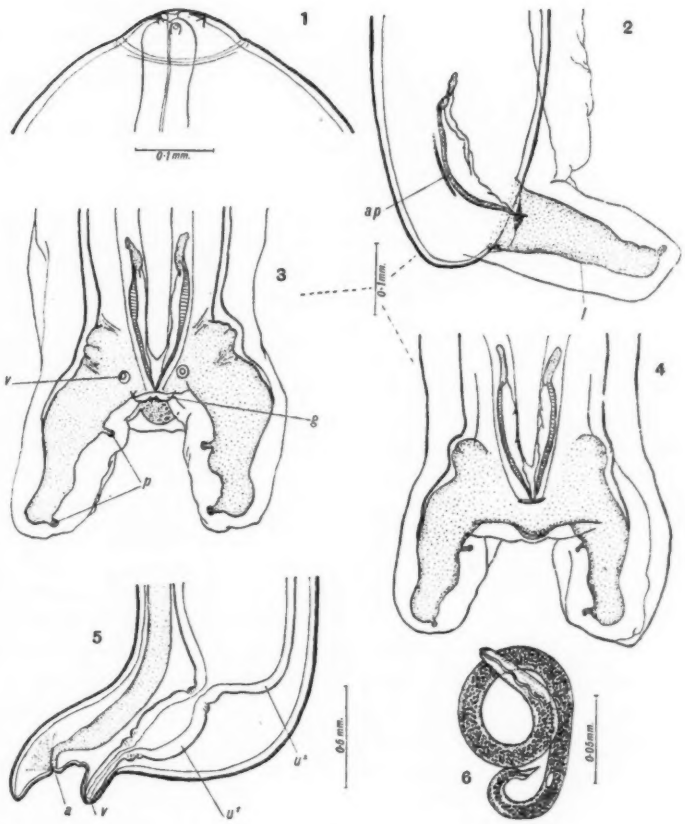
It is noteworthy that all the species show a remarkable degree of specificity for particular hosts, and of the hosts almost every individual examined proves to be infested. As all the worms are viviparous, and as they are frequently found in blood-vessels as well as in air-passages, it seems not improbable that infection takes place *in utero*. The type-specimens of one species here described (*Halocercus lagenorhynchi*) came from a very young dolphin whose stomach was full of its mother's milk. Failing intra-uterine infection it is difficult to see what chance the embryo would have of entering a new host. Cobbold suggested that fishes might act as intermediate hosts for these worms, but although the Ascarids of marine mammals do appear to have such a life-history, immature forms which might belong to the Strongyle group have never been recorded from fishes.

The nomenclature of the hosts has been revised in accordance with the suggestions of Mr M. A. C. Hinton, of the British Museum (Nat. Hist.), synonyms having been for the most part eliminated.

1. **PSEUDALIUS Dujardin, 1845.** (*S.S.*)

Bursa reduced to two elongated lateral lobes projecting ventrally almost at right angles to the longitudinal axis of the body, and containing each a lateral ray, bearing on its inner surface two papillary terminations, one near the extremity and one near the base. These lobes are joined dorsally by a flange of cuticle in the middle of which there is a slight indication of a dorsal lobe. Spicules short, membranous, folded, not fused at the tips. Posterior end of female bent dorsally in front of the vulva. Tail bluntly conical. Vulva opening at the extremity of a tubular outgrowth.

Genotype *P. inflexus* (Rud., 1809).



Pseudalius inflexus.

Fig. 1. Anterior end of female; lateral view.

Fig. 2. Caudal end of male; lateral view. *a.p.*, accessory piece; *l.*, lateral ray.

Fig. 3. Caudal end of male; ventral view. *g.*, genital cone; *p.*, papillary termination of lateral ray; *v.*, termination of ventral ray.

Fig. 4. Caudal end of male; dorsal view.

Fig. 5. Caudal end of female; lateral view. *a.*, anus; $u.^1$, common trunk of uterus; $u.^2$, right uterine branch; *v.*, vulva.

Fig. 6. Embryo from uterus.

Pseudalius inflexus (Rud., 1809).

(Figs. 1–6.)

SYNONYMS: *Strongylus inflexus* Rudolphi, 1809, 227.
„ Kuhn, 1829 *a*, 150.
„ „ „ 1829 *b*, 139.
„ „ „ 1829 *c*, 363, 367, Pl. XVII *bis*, figs. 14–17.
Strongylus inflexus major Raspail, 1829, 250.
S. major Raspail, 1829, 251, Pl. VII, figs. 4–7, Pl. VIII, figs. 2–4, 7–8.
Pseudalius filum Dujardin, 1845, 135.
Prosthecosacter inflexus Diesing, 1851, 323.
? *Prosthecosacta convolutus* Cobbold, 1864, Pl. VI, fig. 3.
Pseudalius inflexus Schneider, 1866, 173, Pl. XII, fig. 10.
? *Prosthecosacter convolutus* Cobbold, 1879, Fig. 70 (p. 424).
nec Stenurus inflexus Dujardin, 1845, 266.

Host. Common Porpoise (*Phocaena phocaena*).

Hab. Bronchi, blood-vessels and heart.

A large and relatively stout species. Body relatively thick anteriorly, tapering posteriorly, more markedly so in the male. Male 120–140 mm. in length, 1·2 mm. in maximum thickness. Female 120–160 mm. and 1·4 mm. respectively. Anterior end bluntly conical. Mouth circular, very small (diameter 0·02 mm.). No buccal capsule, but the invaginated cuticle of the mouth forms a small vestibule 0·005–0·007 mm. deep. A little behind the anterior end the cuticle shows an annular fold, the head being to some extent retractile. Oesophagus only slightly swollen posteriorly, 0·73–0·8 mm. in length, and 0·15 mm. in maximum thickness. Posterior end of male furnished with a recognizable genital cone, with a serrated posterior margin. For some distance in front of the lateral lobes the cuticle of the body is inflated (Figs. 2–4). Spicules 0·24–0·26 mm. long, enclosed in well-marked sheaths. An imperfectly-chitinised accessory piece present. Tail of female 0·25 mm. long, and the tubular vulvar process about an equal distance from the anus. Combined length of vagina and common trunk of uterus about 0·75 mm. Each branch of the uterus extends forward to about the junction of the anterior and middle thirds of the body, and turns posteriorly as an oviduct. Viviparous, at least when fully mature. Embryos 0·35–0·38 mm. long, with a small cephalic button and an obliquely truncate tail.

2. STENURUS Dujardin, 1845.

SYNONYMS: *Pharurus* Leuckart, 1848; *Prosthecosacter* Diesing, 1851.

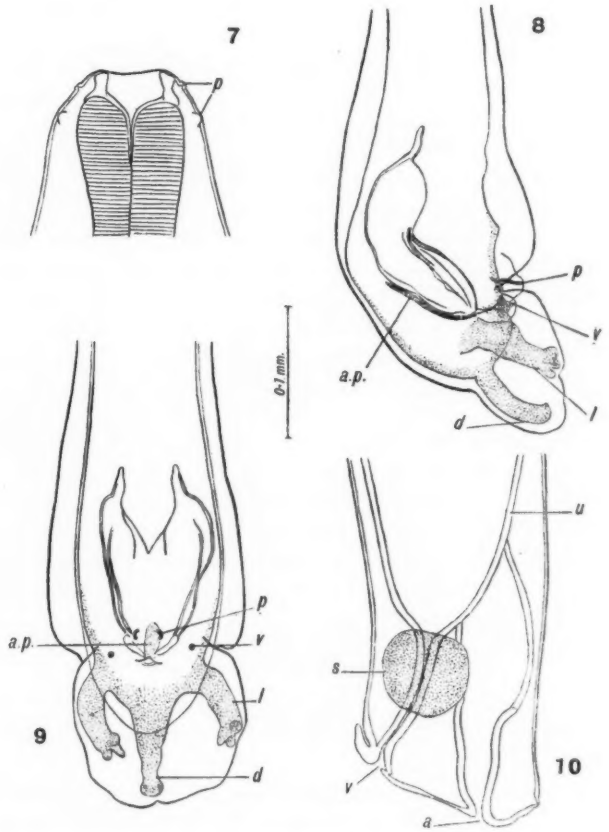
A shallow buccal capsule present. Bursa fairly well developed, more or less divided into a dorsal lobe and a pair of lateral lobes. Each of the latter contains a lateral and a ventral ray. Each lateral ray has a trilobate extremity, with a single papillary termination on its inner surface. Each ventral ray has also a single termination. Dorsal ray relatively elongated, especially in the genotype, and with a pair of ventral terminations near its tip. Spicules typically

broad, membranous, folded, and apparently fused at their tips. A flattened, tongue-shaped accessory piece present. Tail of female truncate, with a small terminal button situated dorsally. Anus subterminal. Vulva with a cuticular process or swelling on its anterior lip. Viviparous.

Genotype: *S. minor* (Kuhn, 1829).

Stenurus minor (Kuhn, 1829).

(Figs. 7–10.)



Stenurus minor.

Fig. 7. Anterior end of female; lateral view. *p.*, submedian papillae.

Fig. 8. Caudal end of male; lateral view. *a.p.*, accessory piece; *d.*, dorsal ray; *l.*, lateral ray; *p.*, prebursal papilla; *v.*, ventral ray.

Fig. 9. Caudal end of male; ventral view. Lettering as in Fig. 8.

Fig. 10. Caudal end of female; lateral view. *a.*, anus; *s.*, sphincter; *u.*, common trunk of uterus; *v.*, vulva.

SYNONYMS: *Strongylus minor* Kuhn, 1829 *a*, 152.
" " " 1829 *b*, 139.
" " " 1829 *c*, 363; Pl. XVII *bis*, figs. 10–13.
" " Raspail, 1829, 246, Pl. VII, figs. 1–3, 8.
Stenurus inflexus Dujardin, 1845, 266 (*nec Strongylus inflexus* Rud., 1809).
Prosthecosacter minor Diesing, 1851, 323.
Prosthecosacter (*Stenurus*) *minor* Diesing, 1861.
Pseudalius minor Schneider, 1866, 174, Pl. XII, fig. 7.
Pharurus minor Cobbold, 1879, 423.
Pseudalius minor v. Linstow, 1888 *a*, 235, Pl. XVI, figs. 1–8.

Host. Common Porpoise (*Phocaena phocaena*).

Hab. Bronchi, tympanic cavity and blood-vessels, especially the venous sinuses of the head.

A small species, the male measuring up to 21 mm. and the female up to 26 mm. in length. Maximum thickness: male 0·42 mm., female 0·63 mm. Body relatively stout in anterior half, slender and tapering posteriorly. Diameter of head, at level of posterior papillae, 0·09–0·11 mm. Buccal capsule moderately well developed, measuring 0·023–0·028 mm. in length. At its anterior end its diameter is 0·053–0·063 mm., at its posterior end 0·063–0·07 mm. Oesophagus (together with buccal capsule) 0·44–0·55 mm. long, somewhat club-shaped behind. Cervical papillae at 0·26–0·3 mm., nerve-ring at 0·125–0·15 mm., from anterior extremity. Posterior end of male (Figs. 8–9) with fairly well-developed, almost circular, bursa, not distinctly divided into lobes. In front of it the cuticle of the body is inflated for some distance, this inflation ending posteriorly in two prominent, rounded, laterally-projecting angles. Lateral rays fairly distinctly trilobate at their extremities. Dorsal ray rather long and slender. In addition to the ventral rays, a pair of slender prebursal papillae present in front of the cloacal aperture, near the mid-ventral line. Spicules about 0·16 mm. long. Accessory piece of uncertain size, imperfectly chitinised.

Vulva at 0·12 mm. from the posterior extremity, with an anteriorly-directed finger-shaped cuticular process on its anterior lip. Von Linstow (1888) figures two such processes, but this appears to be an error. Combined length of vagina and common trunk of uterus 1·05 mm.

Stenurus globicephalae, sp.n.

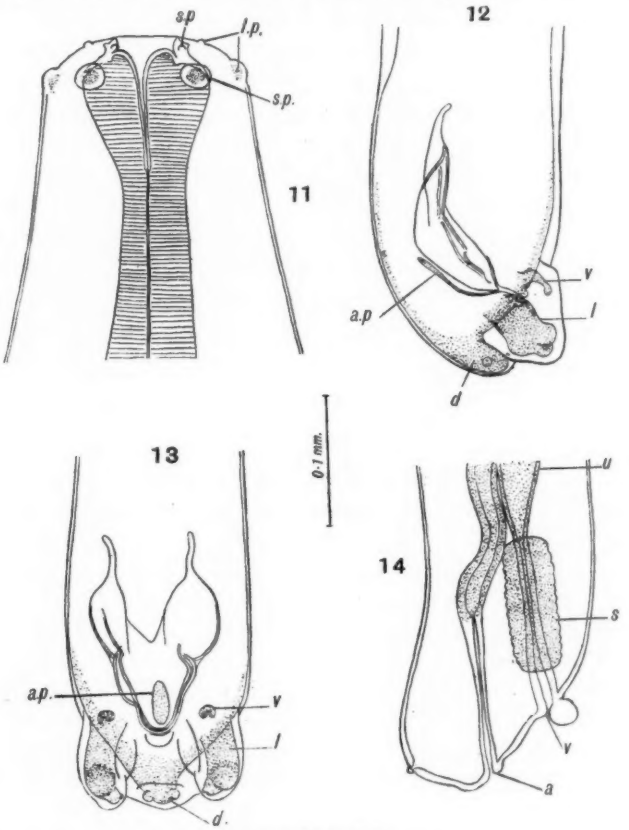
(Figs. 11–14.)

Host. Ca'ing Whale or Blackfish (*Globicephala melaena*).

Hab. At base of blow-hole.

Somewhat larger than the genotype. Average length, male, about 30 mm.; female, about 45 mm. Maximum thickness 0·37 mm. and 0·55 mm. respectively. Diameter of head, at level of posterior papillae, about 0·15 mm. Walls of buccal capsule measure 0·025–0·037 mm. in length, but only project freely from the oesophagus for a very short distance. Width of capsule at opening 0·033–0·05 mm.; at posterior limit of walls 0·075–0·1 mm. Cuticular lining of oesophagus thickened for some distance at anterior end, forming an oesophageal funnel. Oesophagus (together with buccal capsule) 0·56–0·65 mm. long,

somewhat club-shaped behind. Cervical papillae at 0·35 mm. from anterior end (female); nerve-ring at 0·2–0·23 mm. Posterior end of male (Figs. 12–13) with bursa less well developed than in the genotype, and more distinctly divided into three lobes. In front of it the cuticular inflation is only slight. Lateral rays stout, their three terminal lobes stumpy and not well developed.



Stenurus globicephalae.

Fig. 11. Anterior end of female; ventral view. *l.p.*, lateral papillae; *s.p.*, submedian papillae.

Fig. 12. Caudal end of male; lateral view. *a.p.*, accessory piece; *d.*, dorsal ray; *l.*, lateral ray; *v.*, ventral ray.

Fig. 13. Caudal end of male; ventral view. Lettering as in Fig. 12.

Fig. 14. Caudal end of female; lateral view. *a.*, anus; *s.*, sphincter; *u.*, common trunk of uterus; *v.*, vulva.

Dorsal ray short and stumpy. No prebursal papillae observed. Spicules about 0·15 mm., accessory piece about 0·07 mm. long. Vulva at 0·09 mm. from the posterior end, with a spherical cuticular swelling on its anterior lip. Combined length of vagina and common trunk of uterus 1·04 mm.

Co-types in the British Museum (Natural History).

The next three species should probably be referred to this genus. *S. alatus*, however, appears to combine certain characters of the general *Stenurus* and *Halocercus*. In the absence of material for examination we hesitate to assign it to a definite position.

Stenurus arcticus (Cobb, 1888).

SYNONYMS: *Strongylus pallasii* Van Beneden, 1870, 366 (*nomen nudum*).
Strongylus arcticus Cobb, 1888, 64, Figs. 31, 32.
„ „ „ 1889, 150, Pl. VII, figs. 9, 10.
Pseudalius arcticus v. Linstow, 1906, 114.

Host. Whitefish or White Dolphin (*Beluga leucas*).

Hab. "Hearing organs" [probably tympanic cavity].

Van Beneden gave no description of his species, which was based on specimens recorded by Pallas. There is little doubt, however, that Cobb's species is the same. Length, male, 18–22 mm.; female, 21–28 mm. In the male, two pairs of lateral papillae some distance in front of the bursa. The latter is said to have six lobes. Spicules 0·2 mm. long, enlarged distally.

Stenurus ovatus (v. Linst., 1910).

SYNONYM: *Pseudalius ovatus* v. Linstow, 1910, 133–135, Figs. 1–3.

Host. Bottle-nosed Dolphin (*Tursiops truncatus* [*T. tursio*]).

Hab. Oesophagus and stomach [?].

Strongylus alatus Leuckart, 1848.

SYNONYMS: *Strongylus alatus* Leuckart, 1848, 26, Pl. II, fig. III, *A–D*.
Prosthecosacter alatus Diesing, 1851, 324.
Strongylus (*Pharurus*) *alatus* (Leuck.) Diesing, 1851, 325.
Pseudalius alatus v. Linstow, 1888 *b*, 15–17, Pl. XVI, figs. 1–6.
nec Strongylus alatus v. Linstow, 1879.

Host. Narwhal (*Monodon monoceros*).

Hab. Pharyngeal cavities, mouth, Eustachian tubes; "cranial cavity" [probably in blood-sinus].

Length, male 16 mm.; female 16·5 mm., according to von Linstow. (Length 5–6 lines, according to Leuckart.) Cuticle of mouth slightly thickened. Posterior end of male apparently very similar to that of *S. minor*. Spicules relatively long (0·84 mm.), slender and alate, apparently not fused at the tips.

3. **TORYNURUS** n.g.[1].

Posterior end of male somewhat thickened and terminating in a bursa which is ventrally placed and roughly circular in outline, and not clearly divided into lobes. Into the bursa project a pair of large lateral rays and a

[1] A new genus is proposed for the following reason. Stiles and Hassall (1905) designated the species *minor* as type of *Prosthecosacter*, but remarked at the same time that the genus *Prosthecosacter* Diesing was invalid, being a synonym either of *Pharurus*, *Pseudalius* or *Stenurus*. The necessity of choosing a genotype for *Prosthecosacter* from the types of existing genera included by Diesing in *Prosthecosacter* invalidates the genus. *P. convolutus*, the only included species not already a genotype, must therefore be referred to a new genus. [See rule stated by Stiles and Hassall, 1905, p. 47.]

short posterior ray. Ventrally, in front of the bursa, there is an area surrounded by a free cuticular border and containing an elongated, median, muscular, sucker-like organ. Spicules slender, with membranous alae extending for a considerable part of their length, and filiform unfused tips. An accessory piece present. Posterior end of female as in *Stenurus*.

Genotype: *Torynurus convolutus* (Kuhn, 1829).

Torynurus convolutus (Kuhn, 1829).

(Figs. 15–17.)

Synonyms: *Strongylus convolutus* Kuhn, 1829 *c*, 365, Pl. XVII *bis*, figs. 6–9.
Prosthecosacter convolutus Diesing, 1851, 324.
" " Cobbold, 1864, 91.
Prosthecosacta convolutus Cobbold, 1864, Pl. VI, figs. 1, 2, 4 (*nec* fig. 3), Pl. VII.
Pseudalius convolutus Schneider, 1866, 174, Pl. XII, fig. 8.
Prosthecosacter convolutus Cobbold, 1879, 423, Fig. 71 (*nec* Fig. 70).
? *Pseudalius bicostatus* v. Linstow, 1906, 114, Fig. 7.

Host. Common Porpoise (*Phocaena phocaena*). Also recorded from the Ca'ing whale (*Globicephala melaena*).

Hab. Bronchi and pulmonary blood-vessels.

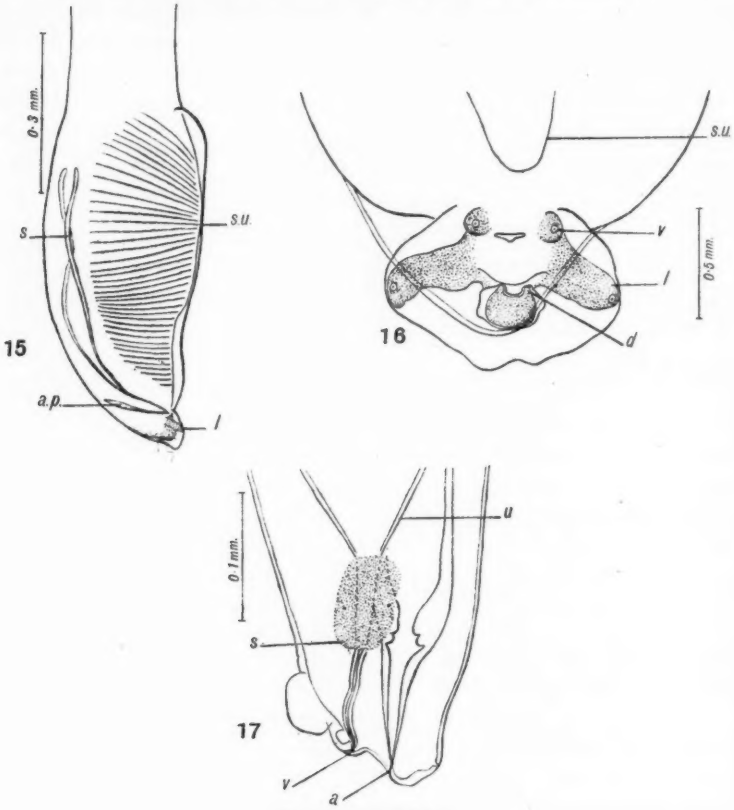
Length, male, up to 38 mm.; female, up to 45 mm. Maximum thickness, 0·3 mm. and 0·45 mm. respectively. Diameter of head, at level of posterior papillae, 0·08–0·09 mm. The small anterior cephalic papillae very indistinct, indicated only by slight irregularities in the surface of the cuticle. Posterior papillae also very low, especially the lateral pair. No buccal capsule, but cuticle slightly thickened where it is invaginated to form the mouth. Oesophagus 0·57–0·67 mm. long, somewhat club-shaped behind. Cervical papillae at 0·27–0·29 mm. from anterior end. Nerve-ring at about 0·145 mm. from anterior end (female). Spicules about 0·6 mm. long, accessory piece about 0·13 mm. Vulva at 0·04 mm. from posterior end, with a small vesicular swelling on its anterior lip and a larger, subspherical swelling a little further forward on the ventral surface. Combined length of vagina and common trunk of uterus 0·8 mm.

Note. There appears to be nothing in the description of *Pseudalius bicostatus* v. Linstow, 1906, to indicate definitely that it is distinct from *Torynurus convolutus*, and the host and habitat are the same. The species is therefore provisionally included in the synonymy of *Torynurus convolutus*.

4. **HALOCERCUS** n.g.

Posterior end of male somewhat conical, furnished in the genotype with a very much reduced, ventrally-placed bursa, not clearly divided into lobes. Bursal rays extremely short and thick. Spicules relatively long and slender, tubular towards the root and alate distally, not fused at the tips. Tail of female truncate or bluntly conical. Lips of vulva without definite cuticular swellings.

Genotype: *Halocercus delphini* sp.n.



Torynurus convolutus.

Fig. 15. Caudal end of male; lateral view. *a.p.*, accessory piece; *l.*, lateral ray; *s.*, spicules; *su.*, sucker-like organ.

Fig. 16. Caudal end of male; ventral view. *d.*, one of the terminations of the dorsal ray; *l.*, lateral ray; *su.*, edge of sucker-like organ; *v.*, ventral ray.

Fig. 17. Caudal end of female; lateral view. *a.*, anus; *s.*, sphincter; *u.*, common trunk of uterus; *v.*, vulva.

Halocercus delphini sp.n.

(Figs. 18–21.)

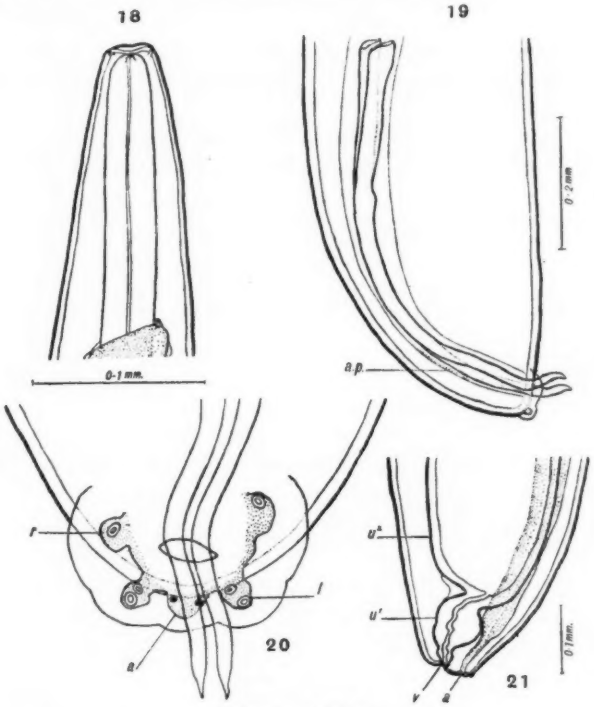
Host. Common Dolphin (*Delphinus delphis*).

Hab. Bronchi.

Length, male 50–65 mm.; female 60–90 mm. Maximum thickness, male, 0·43 mm.; female, 0·5 mm. Cephalic papillae inconspicuous. Mouth small, with a slight cuticular invagination. Oesophagus cylindroid, about 0·6 mm. long and 0·03 mm. in maximum thickness. Nerve-ring at about 0·16–0·18 mm. from anterior end. No cervical papillae or excretory pore seen. Bursa disc-like, with margin slightly indented between the rays. Lateral rays and dorsal

ray each with two papillary terminations, ventral rays with a single sessile termination. Spicules 0·73–0·76 mm. long. Accessory piece very faintly indicated. Testis extends forward to the level of the posterior end of the oesophagus. Combined length of vagina and common trunk of uterus about 0·12 mm. Female genital tubes extend forward to about the junction of the anterior and middle thirds of the body. Embryos 0·26–0·285 mm. long.

Co-types in the British Museum (Natural History).



Halocercus delphini.

Fig. 18. Anterior end of female; lateral view.
Fig. 19. Caudal end of male; lateral view. *a.p.*, accessory piece.
Fig. 20. Caudal end of male; ventral view. *a.*, dorsal ray; *l.*, lateral ray; *r.*, ventral ray.
Fig. 21. Caudal end of female; lateral view. *a.*, anus; $u.^1$, common trunk of uterus; $u.^2$, left uterine branch; *v.*, vulva.

The scale below Fig. 18 refers to that figure only, and not to Fig. 20.

Halocercus lagenorhynchi sp.n.

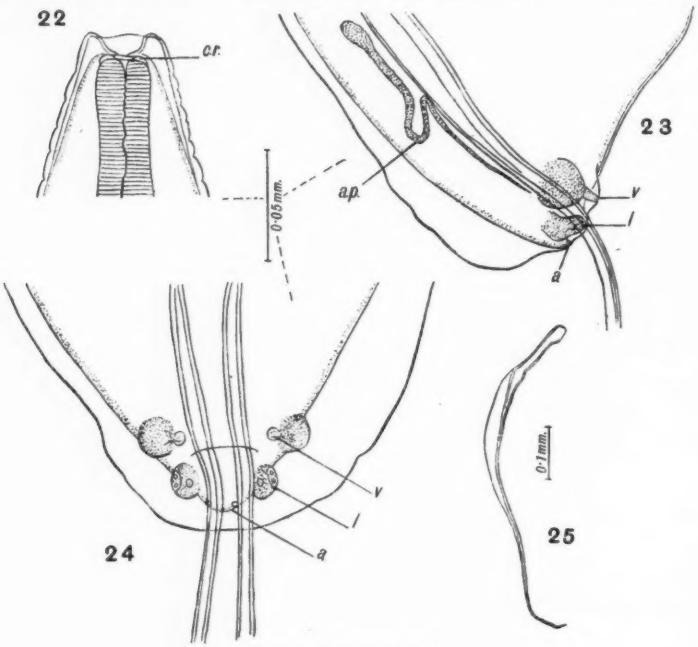
(Figs. 22–25.)

Host. White-beaked Dolphin (*Lagenorhynchus albirostris*).

Hab. Bronchi.

No complete specimens of this species were available, owing to the difficulty of extracting them undamaged from the preserved lung. Length of longest

fragment (female, without head or tail) 93 mm. Maximum thickness, male about 0·34 mm.; female, 0·4 mm. Anterior end tapering and slender. Cephalic papillae not observed. Head usually retracted so that the mouth is situated at the bottom of a cuticular funnel. Oesophagus cylindroid, extremely short (about 0·2 mm.). At its anterior end there appears to be a flattened cuticular ring, possibly representing a buccal capsule. Nerve-ring apparently situated at about the anterior third of the oesophagus. No cervical papillae or excretory pore seen. Posterior end of male with somewhat inflated cuticle. Arrangement



Halocercus lagenorynchi.

Fig. 22. Anterior end of female. *c.r.*, cuticular ring.
Fig. 23. Caudal end of male; lateral view. *a.p.*, accessory piece; *a.*, dorsal ray; *l.*, lateral ray; *v.*, ventral ray.
Fig. 24. Caudal end of male; ventral view. Lettering as in Fig. 23.
Fig. 25. Right spicule.

of bursal rays corresponds to that described for the genotype, but the membranous part of the bursa is indistinguishable from the general cuticle. Outer termination of lateral rays double. Termination of ventral rays pedunculate. Spicules about 0·65 mm. long. Accessory piece relatively well developed, with a double fold at about its middle. Length of accessory piece about 0·1 mm., not including the fold. Vulva at 0·088 mm. from posterior end. Combined length of vagina and common trunk of uterus 0·63 mm.

Co-types in the British Museum (Natural History).

Halocercus gymnurus (Raill., 1899).

Synonym: *Pseudalius gymnurus* Railliet, 1899, 129.

Host. Common Seal (*Phoca vitulina*).

Hab. Bronchi [?].

Length, male, 15–18 mm.; female, 22–23 mm. Maximum thickness, male, 0·12 mm.; female, 0·17 mm. Bursa, rays and papillae said to be absent. Spicules 0·042–0·047 mm. [? 0·42–0·47 mm.] long, slightly curved, constricted near base, then thickened and tapering distally.

This species was referred doubtfully to *Pseudalius* by Railliet. We have placed it tentatively in the genus *Halocercus* on account of the structure of the spicules.

DOUBTFUL FORMS.

Pseudalius tumidus Schneider, 1866.

(Schneider, 1866, 174. Pl. XII, fig. 9.)

Host. Common porpoise (*Phocaena phocaena*).

Hab. Alveoli of lungs, in nodules.

Length, male, 15 mm.; female, 55 mm. Head small and indistinct. Cuticle greatly thickened, with many longitudinal and transverse folds. Vulva close to anus. Viviparous. Tail of male with a scarcely visible bursa and three indistinct ray-like papillae. Spicules slender, curved.

The description of this form does not enable its position to be determined. It is not impossible that Schneider's specimens belonged to the same species as those named *Filaria inflexocaudata* by von Siebold (see following note), also from nodules in the lungs of porpoises.

Note on **"Filaria" inflexocaudata** v. Siebold, 1842.

There is in the collection of the British Museum a single fragmentary and very poorly-preserved male specimen bearing the label "*Filaria inflexocaudata* Siebold," to which has been added, in Baird's handwriting, "? *Pseudalius* Dujard."

Von Siebold[1] refers to small worms recorded by Eschricht and by Quekett from nodules in the lungs of porpoises (*Phocaena phocaena*). Eschricht[2] mentions a worm which he names *Strongylus vagans*[3], while Quekett[4] speaks of one which he calls *Strongylus invaginatus*. Neither author gives anything that can be called a description, and it is impossible to decide whether they were dealing with the same or with different species. V. Siebold assumes, however, that the worm was, in each case, identical with one which he had previously observed, and to which he had given the name (in MS., in 1837) of *Filaria*

[1] *Arch. f. Naturg.* VIII. ii. p. 348 (1842).

[2] *Frorieps Neue Notizen*, XX. No. 433, p. 231 (1841).

[3] The name *Strongylus inflexus pulmonalis*, attributed to Eschricht by v. Siebold and by Diesing [*Syst. Helm.* II. 281 (1851)] in the synonymy of *Filaria inflexocaudata*, does not appear to have been used by Eschricht.

[4] *Ann. Mag. Nat. Hist.* VIII. 151 (1842).

inflexocaudata. He states, further, that the worm cannot be a *Strongylus* because of the absence of a bursa and the possession of a "short double penis," and also that he had seen the vulva, as in *Filaria*, close to the mouth.

The British Museum specimen is one from von Siebold's own collection, and there can be no doubt that it belongs to his species, of which it is probably a co-type. The little that can be made out of its structure indicates that it is related to the species here included in the new genus *Halocercus*. The two spicules are unfortunately broken off short, but they appear to have been of the slender type met with in that genus, and not of the broad, membranous type. In any case they were certainly not unequal and dissimilar, as is usually the case in Filariids. There appears to be no bursal membrane, but nothing can be said as to the bursal rays or papillae. The anterior end of the specimen is missing.

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(*MS. received for publication* 19. II. 1925.—Ed.)

ADDENDUM.

We have already suggested that *Pseudalius tumidus* Schneider, 1866, may be synonymous with *Filaria inflexocaudata* von Siebold, 1842. Since the preparation of our paper further material has come to hand, through the kindness of M. R.-Ph. Dollfus, of the Muséum National d'Histoire Naturelle, Paris, including specimens which confirm this view. These consist of a number of small worms enclosed in nodules from the lungs of a porpoise (*Phocaena phocaena*), each nodule containing about five or six individuals. These worms evidently belong to the same species as the single fragmentary specimen of *F. inflexocaudata* referred to in our paper, while they also agree with Schneider's brief description of *P. tumidus*, which is recorded from similar nodules. Further, the structure of the caudal end of the male and the form of the spicules show that the species belongs to the genus *Halocercus*.

The material is not very well preserved, and the following brief description is necessarily confined to essential characters.

Halocercus inflexocaudatus (von Siebold, 1842).

SYNONYMS: *Filaria inflexocaudata* v. Siebold, 1842, 348[1].
Pseudalius tumidus Schneider, 1866, 174.
?*Strongylus vagans* Eschricht, 1841, 231.
?*Strongylus invaginatus* Quekett, 1842, 151.

Host. Common porpoise (*Phocaena phocaena*).

Hab. Nodules in lungs.

Body elongated, slender, tapering towards each end, especially anteriorly. Cuticle appears thin, loose and irregularly folded. These characters, doubtless, are responsible for Schneider's statement that the thickness of the cuticle is greater than a quarter of the diameter of the body. Length, male, up to about 20 mm. No complete female specimen available in present material (Schneider gives 55 mm.). Maximum thickness, male, about 0·25 mm.; female, 0·35 mm. Cephalic papillae apparently as in other species, but inconspicuous. A very shallow cuticular buccal ring (cf. *H. lagenorhynchi*) apparently present. Oesophagus very short (0·18–0·195 mm.) and slender (maximum thickness in

[1] The complete references will be found as footnotes to that part of the text of our paper dealing with these species.

female 0·025 mm.). Nerve-ring at about 0·058–0·067 mm. from the anterior end. No cervical papillae or excretory pore seen. Bursa apparently absent. The usual rays are present, but their terminations have not been made out. Spicules about 0·2 mm. long. Accessory piece imperfectly chitinised, apparently about 0·055 mm. long. Tail of female relatively rather more elongated than usual in the group, the anus being separated by a distance of 0·0375 mm. from the extremity, which, however, is bluntly rounded. Vulva at 0·1 mm. from posterior end. Combined length of vagina and common trunk of uterus 0·35 mm.

NOTES ON *HOPLITOPHRYA* (*ANOPLOPHRYA*) *BRASILI* (LÉGER AND DUBOSCQ), AN INTESTINAL CILIATE OF THE POLYCHAETE WORM *CIRRATULUS*.

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(With 2 Text-figures.)

In the course of investigations on the Gregarines of *Cirratulus* (*Audouinia*) *tentaculatus* Mont., I have frequently noticed a large astomatous ciliate in the intestine. This appears to be *Anoplophrya brasili* described by Léger and Duboscq in 1904. One or two points, however, have led me to make a closer study of this organism, and I have come to the conclusion that it should be removed from the genus *Anoplophrya*.

The detailed classification of this group of astomatous ciliates is still very unsatisfactory. Cépède (1910) has divided the family of the Anoplophryidae into "Anoplophryidae inermes" and "Anoplophryidae armées." In the former he places *Anoplophrya* and *Bütschliella*, and in the latter *Hoplitophrya* and one or two other genera. The main point of difference between the two groups lies in the presence or absence of a definite "fixing apparatus" of "chitinous" material, supported by a basal piece. This is regularly found in *Hoplitophrya*, but is entirely absent in *Anoplophrya*, while in *Bütschliella* we find a semi-protrusible papilla of ectoplasm with no basal support.

In the ciliate from *Cirratulus* there is a well-marked differentiation of the ectoplasm of the anterior end of the organism. Léger and Duboscq observed this, but were not clear as to its nature: "À l'extrémité antérieure existe une dépression réniforme ou cordiforme que nous interprétons comme une bouche. Il nous est impossible de reconnaître dans cette formation les crochets des *Hoplitophrya*. Limitée par deux lèvres, une supérieure et une inférieure, la bouche apparaît en clair et se prolonge en arrière comme par un court pharynx. Dans cette bouche fait saillie une petite lame effilée ou dent, mot que nous adopterons sans le trouver très juste, puisque la dent n'est pas chitineuse."

A close examination of the anterior end has shown me that it is impossible to justify Léger and Duboscq's interpretation of this apparatus as a mouth. As the ciliate turns over, one can see in side view that there is a small, rounded, non-ciliated papilla, projecting slightly from the periplast. This

papilla is apparently continuous with the periplast, and is probably a specialized part of it, but it is not "chitinous." In a ciliate measuring 380 μ by 110 μ the papilla was about 5 μ in diameter. Posterior to this is to be found a clear, somewhat pear-shaped vacuole, which is doubtless the "dépression réniforme ou cordiforme" of Léger and Duboscq, as it has that appearance when viewed from above or below and is plainly figured by them. There is, however, no opening into it from the exterior, which could be called a mouth. A similar vacuole has occasionally been observed by Mackinnon and Adam (1924) in

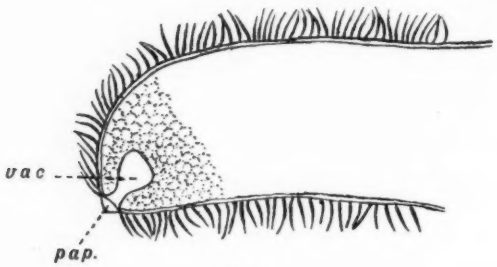

Fig. 1.

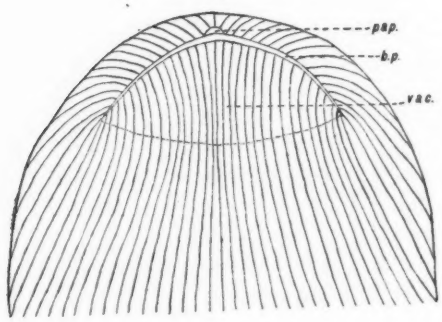

Fig. 2.

Hoplitophrya (*Anoplophrya*) *brasili*. ×625 approx.

Fig. 1. Anterior end seen in side view (optical section).

Fig. 2. The same, seen from the ventral surface (only about half the number of striations are figured and the cilia have been omitted).

b.p. basal piece; *pap.* papilla; *vac.* vacuole.

Bütschliella naïdos (Dujardin). The papilla is supported by a U-shaped, but very slender, basal piece, lying ventral to the vacuole: it is more refringent than the rest of the ectoplasm and presumably "chitinous." The limbs of the U are directed posteriorly, embracing the vacuole, and in the specimen mentioned above were about 32 μ in length. They lie quite superficially and pull in the periplast, causing the formation of a pair of grooves on either side, down towards which the longitudinal striations run. Presumably these are the lips referred to by Léger and Duboscq.

There is some doubt as to the function of this papilla. In the ciliates where there is a very definite apparatus of hooks, etc., as in species of *Hoplitophrya* and *Intoshellina*, this is always spoken of as an organ of fixation. Observation of the species under consideration leads me to the conclusion that the papilla is rather a thrusting organ, used by the ciliate for pushing its way through the detritus in the intestine. I noticed that, when the ciliates are moving about freely on the slide, the anterior end is slightly arched upwards, in such a way that the papilla is elevated and consequently becomes the most anterior part of the organism, and thus the most likely to come in contact with any obstacle. On meeting with any *débris* or other solid mass, the papilla is kept tightly pressed against it, the whole organism often turning over as the obstruction is pushed to one side.

Unlike the free-living ciliates, such as *Paramecium*, the ciliate from *Cirratulus* does not reverse immediately on coming in contact with an obstacle, but holds on its course and endeavours to burrow its way through, only reversing when it finds this impossible. This is probably a common feature among intestinal ciliates, such as *Opalina*, living among a certain amount of solid matter, and I observed (1924) a similar determined behaviour in *Cryptochilum boreale* from *Echinus*.

Whether this explanation will apply to those astomatous ciliates with more complicated skeletal apparatus, requires further investigation; but it is noteworthy that nowhere in the literature do there seem to be any figures of ciliates using their so-called "fixing apparatus" to attach themselves to the intestinal epithelium. In the present case, the rounded shape of the papilla makes it very unlikely that it is an organ of fixation, for it is difficult to see how such a structure could obtain any hold. It seems much more probable that what we have here is something of the nature of a "buffer," and it is possible that the vacuole lying behind may be some sort of hydraulic apparatus, which acts as a "shock absorber," analogous to the familiar compressed-air buffers at railway termini. A similar function is probably to be assigned to the projection in *Bütschliella naïdos* (Dujardin), described by Mackinnon and Adam (1924), who speak of it as follows: "What the function of this structure is, we are unable to say. Possibly the presence of the vacuole behind it facilitates the flattening of the beak-like projection against a resistant surface. We cut sections of infected worms. From these it is clear that the beak merely rests on the hummocks caused by the epithelial cells; it does not pierce them in any way."

The geographical distribution of the ciliate from *Cirratulus* seems to be rather wide. It has been recorded from many parts of the French coast by various workers (for details of which reference should be made to Cépède (1910)). I have obtained most of my material from Plymouth, but I have also found heavy infections in *Cirratulus* at Fetlar in the Shetland Islands. Further, at the Woods Hole Marine Biological Laboratory, Massachusetts, U.S.A., I observed what appeared to me to be identical ciliates in the intestine of *Cirratulus grandis* Verrill.

In all other points of morphology, my observations have confirmed those of Léger and Duboscq. But owing to the presence of this thrusting apparatus and its basal support, it seems as though the position of this species in the genus *Anoplophrya* is scarcely justifiable, if, with Cépède, we confine that genus to forms totally devoid of any "armature." Further, though showing some affinity to *Bütschliella*, it cannot be included in that genus, owing to the large number of rows of cilia, which in *Bütschliella* are characteristically few. The safest course, therefore, seems to be to place this ciliate provisionally in the genus *Hoplitophrya*, which is defined by Cépède as including those parasites "qui par leur anatomie générale rappellent les *Anoplophryae* et qui présentent à leur extrémité antérieure un appendice fixateur externe chitineux." Careful re-examination, however, of many of the species hitherto included in *Anoplophrya* seems very desirable, in order to ascertain whether there are among these any others possessing a similar apparatus; for it may be necessary to create a new genus, distinct from *Hoplitophrya*, to include such forms.

The following is a brief re-description of the ciliate from *Cirratulus*:

Hoplitophrya brasili (Léger and Duboscq).

Flattened holotrichous astomatous ciliate, varying from 80 μ to 450 μ in length; about 70 longitudinal striations on each surface; at the anterior end provided with a small rounded non-ciliated papilla, supported by a U-shaped basal piece and heart-shaped vacuole; one row of 4, 5 or more contractile vacuoles on the left-hand side; meganucleus long, axial, somewhat gutter-like, with numerous projections into the endoplasm; micronucleus situated on the right-hand side, spindle-shaped, frequently seen in a state of division.

Habitat: Intestine of *Cirratulus* (*Audouinia*) *tentaculatus* Mont., from Calvados, Brittany, Mediterranean coast of France; Plymouth; Fetlar, Shetland; intestine of *C. grandis* Verrill from Woods Hole, Massachusetts, U.S.A.

In conclusion, I wish to express my thanks to Dr D. L. Mackinnon, of King's College, London, for her helpful advice and criticism.

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(*MS. received for publication* 16. II. 1925.—Ed.)

RECHERCHES SUR LA CONCENTRATION MOLÉCULAIRE DES SUCS DES PARASITES.

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(Avec 3 Graphiques.)

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1. INTRODUCTION.

LE nombre des travaux traitant de la concentration moléculaire des sucs et tissus des divers animaux est déjà très grand (Fredericq, Sabbattani, Bottazzi, Quinton), pourtant les parasites ont été négligés. C'est pour combler cette lacune, que nous avons entrepris les recherches dont nous donnons ici les premiers résultats. La détermination des concentrations moléculaires a d'abord un intérêt en elle-même, comme détermination de constante physico-chimique. Elle peut, d'autre part, donner d'utiles renseignements pour l'étude des milieux de culture des grands parasites; elle peut aussi indirectement contribuer à l'étude de la spécificité parasitaire ainsi qu'à celle de la nutrition des parasites intestinaux.

Nous nous sommes posé les questions suivantes:

1. Quelle est la concentration moléculaire des sucs et tissus des parasites (Cestodes, Nématodes, Trématodes)?

2. Quelle est la concentration des milieux dans lesquels ces parasites vivent?

3. Ces chiffres sont-ils vraiment des constantes?

4. Est-ce que ces données peuvent nous éclairer sur les échanges entre le parasite et l'hôte?

5. Quelle est la nature des phénomènes d'osmose présentés par les parasites; relèvent-ils de lois physico-chimiques précises et de quelle interprétation sont-ils susceptibles?

Animaux étudiés:

Nématodes (*Ascaris megalocephala* Cloquet).

Cestodes (*Moniezia expansa* Rudolphi).

Trématodes (*Fasciola hepatica* Linné).

Dans ce premier mémoire il ne sera question que des Nématodes.

2. Technique.

Le point de congélation (Δ) est mesuré à l'aide d'un cryoscope à éther et d'un thermomètre au $\frac{1}{100}°$; on peut facilement lire le $\frac{1}{500}°$ et le $\frac{1}{1000}°$[1].

Il est facile de calculer la pression osmotique en atmosphères, à partir de Δ, si l'on se souvient que 1 molécule gramme dissoute dans 1 litre d'eau, crée un Δ de $-1°,85$ et une P.O. de 22,41 atmosphères. Une correction de température est nécessaire puisque ces animaux vivent à 37° et que la P.O. est fonction linéaire de la température. Comme $\alpha = \frac{1}{273}$ (de même que pour les gaz) on peut appliquer l'équation des gaz parfaits:

$$PV = RT; \text{ comme } V = \frac{1}{c}, \text{ nous avons}$$

$$P = RTc, \qquad R = \frac{22{,}41}{273} = 0{,}0821,$$

$$T = 273° + 37° = 310°.$$

3. Méthode.

Le liquide coelomique d'*Ascaris* est extrait par section de l'extrémité caudale (spécialement des gros individus ♀), ou à l'aide de la seringue de Pravaz. Cette méthode est préférable car en sectionnant l'extrémité caudale on risque d'obtenir un liquide impur mélangé du contenu intestinal de l'*Ascaris*. Les gros individus peuvent donner jusqu'à $1\frac{1}{2}$ c.c. de liquide jaune orangé, clair lorsqu'il est pur. Ce liquide doit être cryoscopé directement. La coagulation du liquide par la chaleur n'a qu'une influence très faible sur le Δ.

Non coagulé $\Delta = -0°,640$.

Coagulé $\Delta = -0°,635$.

Il en est de même pour la filtration. Les différences obtenues rentrent dans la limite des erreurs d'expériences. Le liquide intestinal de cheval est filtré afin d'éliminer les nombreuses particules qu'il renferme.

Il est urgent d'employer des liquides et des animaux aussi frais que possible. En effet, les fermentations changent rapidement l'état physico-chimique du liquide et les résultats obtenus par la cryoscopie ne signifient plus rien.

Liquide coelomique d'*Ascaris*:

Après 5 h.: $\Delta = -0°,620$.

„ 23 h.: $\Delta = -0°,749$.

Liquide intestinal de cheval:

Après 2 h.: $\Delta = -0°,745$.

„ 12 h.: $\Delta = -0°,755$.

„ 36 h.: $\Delta = -0°,851$.

On peut s'étonner de nous voir attacher de l'importance à la cryoscopie du liquide intestinal de cheval; la concentration de ce dernier doit dépendre de la nutrition, de la quantité de liquide absorbé, du moment où l'animal a été

[1] Read degrees Centigrade throughout.—Ed.

abattu. Cependant il est curieux de remarquer que les variations sont moins fortes qu'on pourrait se l'imaginer et que dans les cas que nous avons étudiés, la concentration varie dans des limites relativement faibles étant donné les nombreuses càuses possibles de variations.

A l'abattoir les *Ascaris* sont recueillis sitôt le cheval abattu, et emportés avec le liquide intestinal de ce dernier, correspondant autant que possible à la place qu'occupaient les *Ascaris* dans l'intestin de l'hôte. Mais ce fait n'a pas beaucoup d'importance étant donné les migrations que ceux-ci peuvent effectuer dans l'intestin. Au laboratoire ils sont utilisés immédiatement ou conservés pendant quelques heures à 37°.

4. CRITIQUE DE LA MÉTHODE ET DE LA TECHNIQUE.

Le liquide d'*Ascaris* étant homogène, les résultats sont assez précis, ce qui n'est pas le cas pour l'extrait des tissus de Cestodes. La critique la plus importante est celle-ci: pour obtenir une quantité suffisante de liquide, nous nous sommes, dans nos premières mesures, servi du liquide fourni par plusieurs Nématodes. Or, nous pouvions supposer que la concentration des *Ascaris* d'un même cheval était différente et que le chiffre obtenu n'était qu'une moyenne. Nous avons dans la suite cherché à éliminer cette erreur en nous servant d'un cryoscope à éprouvette interne très petite et avons utilisé le moins d'*Ascaris* possible (4, 3 et même 1). Les résultats que nous avons obtenus montrent qu'il n'y a pas beaucoup d'inconvénients à utiliser plusieurs *Ascaris* à la fois, à la condition bien entendu qu'ils proviennent d'un même animal. Les chiffres obtenus ne se rapportent qu'à la concentration en électrolytes. Les colloïdes ne créent qu'un très faible abaissement du point de congélation qui n'est pas du tout en rapport avec le rôle très important qu'ils jouent dans le gonflement et l'absorption d'eau.

La pression osmotique calculée en atmosphères ne représente donc pas la pression totale, mais seulement la pression due aux électrolytes. Les chiffres obtenus ne doivent être utilisés qu'avec prudence lors de l'étude des échanges d'eau et du sens de ces échanges.

5. RÉSULTATS OBTENUS.

Tableau général.

Nombre de mesures	Quantité de liquide c.c.	Nombre d'*Ascaris*	liquide Δ	Coelomique parasite atmos.	liquide Δ	Intestinal hôte atmos.
1	12	—	−0°,556	7,65	−0°,715	9,84
4	15	12	−0°,632	8,70	−0°,773	10,63
3	6	12	−0°,645	8,87	−0°,774	10,24
2	6	4	−0°,665	9,15	—	—
2	4½	4	−0°,682	9,38	—	—
1	4½	4	−0°,664	9,14	—	—
2	4	10	−0°,650	8,94	−0°,850	11,69
1	5	3	−0°,620	8,53	—	—
3	5	3	−0°,605	8,32	—	—
	4	4	−0°,616	8,47	−0°,674	9,27

Moyenne −0°,633; var. moyenne ±0°,028.

Mesures faites avec le plus petit nombre d'*Ascaris*:

A. Deux groupes de 2 *Ascaris* provenant du même cheval:

(1) $\Delta = -0°,640$. (2) $\Delta = -0°,630$.

B. Deux groupes de 2 *Ascaris* provenant d'un autre cheval:

(1) $\Delta = -0°,605$. (2) $\Delta = -0°,615$.

C. Trois groupes de 3 *Ascaris* provenant d'un autre cheval:

(1) $\Delta = -0°,665$. (2) $\Delta = -0°,665$. (3) $\Delta = -0°,680$.

Nous voyons donc que la concentration du liquide des *Ascaris* de différents chevaux varie, mais dans des limites assez étroites (variation moyenne $= \pm 0°,028$). Ces variations ne sont pas en corrélation avec celles que subit le liquide intestinal. En considérant les *Ascaris* d'un même cheval, nous voyons qu'ils doivent avoir tous un liquide de concentration voisine. Les différences que nous observons entre les différents groupes provenant d'un même cheval, sont inférieures à la variation moyenne ($-0°,01$, $-0°,01$, $-0°,00$, $-0°,015$).

Expériences relatives à la perméabilité de la cuticule et au comportement des animaux dans les solutions hypo- et hypertoniques.

Solutions employées:

Hypotonie: eau distillée et eau courante.

Hypertonie: NaCl à diverses concentrations. Nous avons utilisé surtout la concentration de 16 °/₀₀. Cette solution est bien hypertonique par rapport au liquide ascaridien, puisque ce dernier correspond à une concentr. de 10–11 °/₀₀ de NaCl.

Nous avons également employé la solution de Ringer (en faisant varier le Δ), ainsi que d'autres solutions équilibrées (dont nous parlerons dans un prochain mémoire).

Les *Ascaris* se prêtent bien aux expériences, car ils sont assez résistants (Bunge les a fait vivre pendant huit jours; exp. personnelle: 15 à 21 jours)[1].

Exp. I. 6 *Ascaris* d'un même cheval sont placés dans une solution hypotonique à 37°. Après 1 h., 1½, 4, 5, un *Ascaris* est vidé et son liquide est cryoscopé.

Après	Δ
0 h. 0m.	$-0°,645$
1 h. 0m.	$-0°,586$
1½h. 0m.	$-0°,576$
4 h. 0m.	$-0°,504$
5 h. 0m.	$-0°,480$

Il y a donc pénétration d'eau qui dilue le liquide coelomique.

Nous avons ensuite étudié le gonflement par la méthode gravimétrique.

[1] Une expérience curieuse montre bien leur résistance. Un *Ascaris* est privé de son liquide à l'aide d'une seringue de Pravaz. Une quantité correspondante de solution de Ringer à une concentration convenable lui est injectée; replacé dans de l'eau à 37°, l'*Ascaris* manifeste rapidement des mouvements très vifs. Ils peuvent séjourner pendant plusieurs heures hors de toute solution ils restent nertes; plongés à nouveau dans de l'eau à 37° ils ont des mouvements vifs.

Le fait que les *Ascaris* gonflent et que leurs viscères saillent parfois dans de l'eau ordinaire, est connu depuis longtemps. Leuckart en déduisait que de l'eau pénétrait et concluait à la nutrition cutanée de l'*Ascaris*. Cette interprétation est inexacte.

La courbe du gonflement présente une ascension, un point maximum qui est parfois constant pendant quelques heures, et une descente insensible.

Maximum de gonflement atteint par 5 individus placés dans une solution hypotonique:

$$+ 36{,}79\ \%,\ + 38{,}90\ \%,\ + 19{,}76\ \%,\ + 33{,}10\ \%,\ + 28{,}59\ \%.$$

Dans une solution hypertonique (NaCl à 16 $^{\circ}/_{\circ\circ}$) ils diminuent de poids.

Maximum de diminution atteint par 5 individus:

$$- 14{,}81\ \%,\ -10{,}64\ \%,\ - 8{,}07\ \%,\ - 18{,}19\ \%,\ -11{,}98\ \%.$$

Exp. II. 4 individus placés dans une solution hypotonique donnent les chiffres suivants (les augmentations en % sont portées sur les courbes du graphique I).

Tableau I (*solution hypotonique, eau distillée*).

Après	Poids absolu grammes	+%
0h. 0m.	5,65	—
1h. 30m.	6,65	17,70
3h. 45m.	7,70 éclate	36,28

Tableau II (*solution hypotonique, eau distillée*).

Après	Poids absolu grammes	+%
0h. 0m.	7,10	—
0h. 30m.	7,60	7,04
2h. 30m.	8,90	25,25
4h. 0m.	9,40	32,39
10h. 0m.	9,60	35,21
18h. 0m.	9,45	33,10
19h. 0m.	9,45	33,10

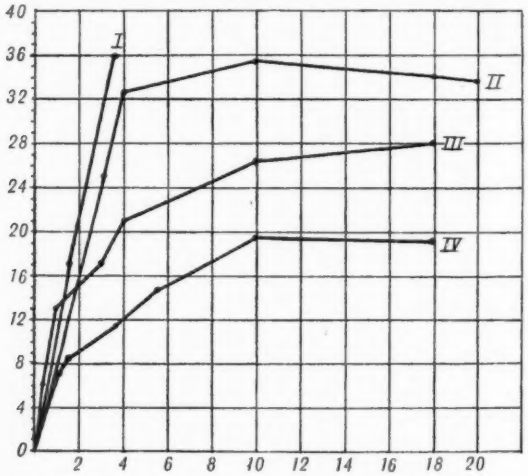
Tableau III (*solution hypotonique, eau distillée*).

Après	Poids absolu grammes	+%
0h. 0m.	4,5	—
0h. 30m.	4,75	5,56
1h. 0m.	5,10	13,34
3h. 0m.	5,30	17,79
4h. 0m.	5,55	23,34
10h. 0m.	5,70	26,67
18h. 0m.	5,80	28,90

Tableau IV (*solution hypotonique, eau distillée*).

Après	Poids absolu grammes	+%
0h. 0m.	3,05	—
1h. 30m.	3,30	8,2
3h. 45m.	3,40	11,48
5h. 30m.	3,50	14,76
6h. 0m.	3,55	16,40
10h. 0m.	3,65	19,67
18h. 0m.	3,65	19,67

Graph. I.



Exp. III. 3 individus placés dans une solution hypertonique (NaCl 16 °/₀₀ et 26°/₀₀) donnent les chiffres suivants (les diminutions en pour cent données par les courbes du graphique II).

Tableau V
(*solution hypertonique* NaCl 16 °/₀₀).

Après	Poids absolu grammes	– %
0h. 0m.	4,75	—
1h. 0m.	4,50	5,26
3h. 0m.	4,25	10,53
5h. 45m.	4,20	11,58
10h. 0m.	4,20	11,58

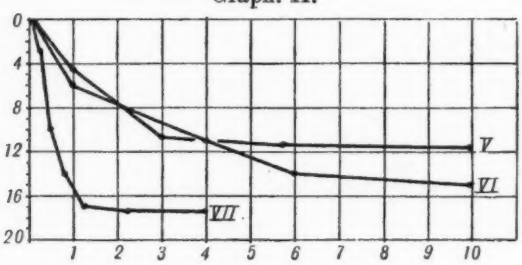
Tableau VI
(*solution hypertonique* NaCl 16 °/₀₀).

Après	Poids absolu grammes	– %
0h. 0m.	6,75	—
1h. 0m.	6,35	5,93
4h. 0m.	5,95	11,85
6h. 0m.	5,80	14,07
10h. 0m.	5,75	14,81

Tableau VII (*solution hypertonique* NaCl 25 °/₀₀).

Après	Poids absolu grammes	– %
0h. 0m.	9,70	—
0h. 15m.	9,40	3,09
0h. 30m.	8,70	10,31
0h. 40m.	8,30	14,43
1h. 15m.	8,05	17,01
2h. 15m.	8	17,53
4h. 0m.	8	17,53

Graph. II.



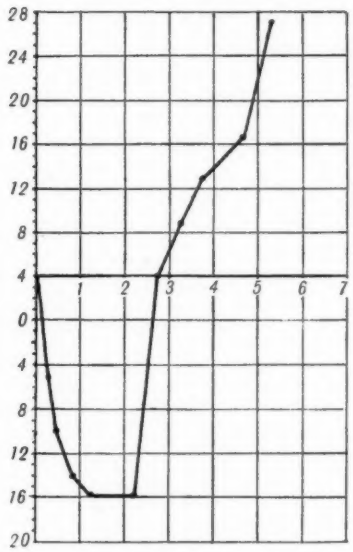
Exp. IV. Un individu placé pendant 2 h. 15 m. dans une solution hypertonique, puis replacé dans une solution hypotonique, donne les chiffres suivants (les augmentations et diminutions en pour cent sont données au graphique III).

Tableau VIII.

Après	Poids absolu grammes	±%
0h. 0m.	12,30	—
0h. 15m.	11,60	− 5,69
0h. 30m.	11	− 10,57
0h. 45m.	10,55	− 14,22
1h. 15m.	10,30	− 16,26
2h. 15m.	10,30	− 16,26
2h. 45m.	12,35	+ 4,07
3h. 15m.	13,50	+ 9,76
3h. 45m.	13,90	+ 13,01
4h. 30m.	14,50	+ 17,89
5h. 15m.	15,70	+ 27,64
14h. 30m.	18,20	+ 47,96

L'augmentation continue.

Graph. III.



Remarque. Au cours des expériences d'hypotonie il arrive que les viscères de l'individu fassent saillie; ces individus sont éliminés; de même, il arrive que l'intestin se vide (voir explication plus loin); ces individus sont également éliminés. Dans trois cas la cuticule était si distendue qu'elle a éclaté.

Cette augmentation et cette diminution de poids causée par l'apport et la sortie de l'eau, nous prouve que la cuticule est perméable à l'eau dans les deux sens, et que jusqu'à un certain point, les *Ascaris* sont susceptibles d'une régulation osmotique. Nous nous sommes demandé si réellement cette régulation se faisait au niveau de la cuticule, et si l'intestin (l'eau ayant pénétré par la bouche), ou l'utérus (l'eau ayant pénétré par le port génital), n'y participaient pas.

Exp. IV. Ascaris placé dans une solution hypotonique. Ses deux extrémités sont liées à l'aide d'un fil de soie (régulation par l'intestin éliminée).

Il y a augmentation de poids.

Exp. V. Ascaris placé dans solution hypotonique; deux extrémités liées et le tiers supérieur de l'animal émerge (régulation par l'utérus éliminée).

Il y a augmentation de poids[1].

Nous pouvons donc dire que c'est surtout au niveau de la cuticule que se fait la régulation osmotique.

[1] Ces expériences sont également valables pour la série hypertonique.

6. Interprétation des Résultats.

L'augmentation et la diminution de poids laissent entendre qu'à une concentration intermédiaire il n'y aura pas changement de poids. Il était intéressant de rechercher si, à ce moment, la solution était isotonique avec le liquide ascaridien (valeur moyenne).

Le Δ d'une solution de NaCl à 10 $^{0}/_{00}$ est $-0°,60$.

$$\Delta = c.\ 1{,}85\ .\ k. \quad c = 0{,}172 \text{ moléc. gramme.}$$
$$k = 1{,}87.$$

La concentration de cette solution est un peu inférieure à celle du liquide ascaridien. Dans cette solution il y a eu stabilité de poids pendant une heure, puis une légère augmentation due probablement au gonflement de la membrane et à une légère endosmose, puisque la solution extérieure était de concentration faiblement inférieure. Dans une solution à 11 $^{0}/_{00}$ la stabilité de poids a duré plus d'une heure. Il est impossible de s'attendre à une stabilité complète, car le gonflement de la membrane se produit même dans une solution isotonique, et dépend d'autres lois. Nous pouvons donc dire que dans une solution de NaCl à 10–11 $^{0}/_{00}$ à peu près isotonique avec le liquide ascaridien, l'augmentation de poids est nulle ou minima. On aura remarqué déjà que les maxima atteints sont différents, et que les allures de courbes sont également différentes pour des *Ascaris* provenant d'un même cheval. Ces différences, comme nous l'expliquerons plus loin, proviennent de la tension de la membrane qui est différente suivant les individus, et de la quantité de liquide contenu dans l'animal. Il est donc impossible de sérier avec certitude les courbes suivant les concentrations des solutions dans lesquelles elles ont été obtenues.

Avant de passer à des considérations plus générales, nous voudrions encore expliquer le phénomène curieux présenté par l'intestin qui se vide. Nous le supposons conditionné par le fait suivant: l'eau en pénétrant dans la cavité coelomique exerce une pression sur la face interne de la cuticule et sur la paroi interne de l'intestin. Or ce dernier, très délicat, et peu tendu, ne supporte pas la pression que la cuticule très résistante peut tolérer. Peu à peu la lumière de l'intestin se rétrécira, et à un moment donné le contenu intestinal sera expulsé. Théoriquement, plus la solution extérieure est hypotonique, plus l'endosmose est rapide, plus la quantité d'eau pénétrante est grande, et plus rapidement le contenu intestinal doit être expulsé. Nous nous sommes demandé si le moment auquel cette expulsion se produit ne dépend pas de la concentration de la solution extérieure. Or ici nous nous heurtons à une double difficulté: nous ignorons la quantité de liquide contenue dans l'animal, et la quantité du contenu intestinal. Comme ces deux données interviennent pour ralentir ou accélérer l'expulsion du contenu intestinal, nous ne devons pas nous attendre à obtenir des faits conformes aux prévisions. Pourtant deux cas sur cinq ont semblé confirmer notre supposition.

Contenu intest.	Eau dist.	NaCl 2 $^{0}/_{00}$	5 $^{0}/_{00}$	7½ $^{0}/_{00}$
Expulsé après	1¼h.	4¾h.	5¼h.	pas exp.

Nous reconnaissons dans nos courbes de gonflement les courbes caractéristiques d'endosmose; celles que nous avons obtenues se rapprochent beaucoup de celles que Laugier et Benard ont obtenues sur le muscle. L'ingénieuse explication de ces auteurs est la suivante: lorsque le muscle est plongé dans de l'eau distillée, il se produit un fort courant d'endosmose et en même temps un faible courant d'exosmose (diffusion) qui commence dès le début de l'expérience, et qui est révélé par l'examen de la conductibilité électrique de l'eau distillée extérieure. Lorsque la courbe d'endosmose atteint son maximum c'est que la tension élastique de la membrane compense la force endosmotique et conditionne son arrêt. Seul le faible courant de diffusion continuera. C'est ce dernier qui causera la faible descente de la courbe. L'arrêt de la courbe d'augmentation n'est donc pas produit par la perte de la "semiperméabilité vitale," ce qui n'expliquerait pas grand'chose, mais par la tension élastique de la membrane limitante. Il nous semble que cette notion s'applique très bien au gonflement des *Ascaris*. Les maximums différents atteints par les différents individus, s'expliquent par cette tension élastique qui doit être différente selon les individus. La quantité variable de liquide contenu dans chaque animal joue aussi un rôle. En effet, si celui-ci ne contient que peu de liquide, il y aura place pour plus d'eau et le maximum sera plus élevé.

C'est précisément l'allure de la courbe lorsqu'elle descend, qui nous renseignera sur le degré de semiperméabilité; si celle-ci est complète, il n'y aura pas d'exosmose et la courbe ne descendra pas ou très peu. Or, dans nos courbes cette descente est faible, ce qui nous prouverait que la cuticule d'*Ascaris* jouit d'une certaine perméabilité. Celle-ci est cependant loin d'être complète, car à la fin de l'expérience V, où l'osmose ne se produit qu'au niveau de la cuticule, le liquide extérieur après une heure d'expérience, fournit un précipité avec $AgNO_3$, indiquant qu'il y a eu diffusion depuis l'intérieur de l'*Ascaris*.

D'autre part, l'interprétation de la courbe III est suggestive. Après avoir diminué de poids dans une solution hypertonique, l'animal plongé immédiatement dans une solution hypotonique (eau distillée), augmente à nouveau de poids. Il semble bien que nous avons là un phénomène dans lequel les concentrations moléculaires jouent le plus grand rôle (sans pour cela exclure l'action d'autres facteurs). Mais il faut remarquer que ces expériences se font *in vitro* hors des conditions physiologiques. Il n'est pas certain que ce qui est juste *in vitro* le soit *in vivo*.

7. CONSIDÉRATIONS GÉNÉRALES.

L'interprétation des phénomènes osmotiques a beaucoup évolué. Le terme osmose a reçu des définitions variées et des extensions curieuses, surtout de la part des biologistes. Si l'on prend le mot dans son sens strict, physico-chimique, osmose signifie passage d'eau au travers d'une membrane semi-perméable. Il est évident qu'aucun phénomène biologique ne satisfait à cette définition idéale et un peu simplifiée[1]. La semiperméabilité complète n'existe

[1] On connaît quelques cas de semiperméabilité biologique qui se rapprochent beaucoup de la semiperméabilité théorique, sans cependant la réaliser complètement (Dekhuijsen).

pas dans la nature; on a coutume (Girard) de ne pas considérer les membranes comme semiperméables, mais comme apportant seulement une perturbation aux lois habituelles de la diffusion. Tout ce que l'on peut dire, c'est que certains processus biologiques se rapprochent de ce phénomène osmotique idéal et qu'ils sont régis surtout par des différences de concentrations moléculaires, tandis que d'autres s'en éloignent (pas de semiperméabilité, intervention d'autres facteurs que la concentration moléculaire; ce sont ces cas d'osmose dite anormale qui sont souvent très importants en biologie). Il est certain que dans aucun phénomène ayant trait à la nutrition de la cellule ou de l'organe, nous ne retrouvons ce phénomène osmotique typique puisque ces processus sous-entendent le passage des molécules dissoutes. Mais il existe des membranes limitantes en contact avec le milieu extérieur, qui ne jouent aucun rôle dans la nutrition et qui sont le siège d'échanges d'eau servant à la régulation osmotique. Dans ce cas, nous nous rapprochons des phénomènes osmotiques typiques. Or, chez les Nématodes la nutrition cutanée ne joue qu'un rôle très effacé. Garin a montré que beaucoup de Nématodes intestinaux se nourrissent aux dépens des parois du tube digestif. Abderhalden et Heise ont prouvé la présence d'un ferment peptolytique dans l'intestin d'*Ascaris*; la muqueuse intestinale d'*Ascaris* placée dans une solution de peptone riche en tyrosine, se couvre en peu d'heures d'abondants cristaux de tyrosine. Ces Nématodes ont donc une nutrition active et nous croyons que la cuticule participe surtout à la régulation osmotique; celle-ci doit être nécessaire puisque le liquide intestinal de l'hôte est soumis à des variations de concentrations moléculaires.

Le gonflement dans l'eau distillée indique seulement le passage de l'eau au travers de la membrane, mais ne sous-entend pas du tout que la cuticule participe d'une façon active à la nutrition.

Nous ne pouvons expliquer la différence constante de pression existant entre le liquide de l'*Ascaris* et le liquide intestinal de l'hôte. Nous ne tentons aucune explication car nous ne sommes pas certain d'avoir toujours obtenu le liquide intestinal correspondant à la place qu'occupait l'*Ascaris* dans l'intestin, au moment où nous l'avons extrait. Si cependant le fait se confirmait, nous pourrions l'expliquer par un équilibre de Donnan[1].

8. Conclusions.

Dans nos expériences nous trouvons que:

1. La concentration moléculaire du liquide coelomique d'*Ascaris megalocephala* correspond à un Δ de $-0°,633$ (variation moyenne $\mp 0°,028$).

2. Elle varie dans des limites assez étroites; ces variations ne sont pas en corrélation avec celles que subit le liquide intestinal.

3. Tous les *Ascaris* d'un même cheval semblent avoir un liquide de concentration moléculaire très voisine.

[1] Dans un prochain mémoire, nous étudierons la réaction du liquide et le rôle que le P_H peut jouer dans la perméabilité.

4. L'*Ascaris* augmente de poids dans une solution hypotonique et diminue de poids dans une solution hypertonique.

5. Un séjour dans une solution hypotonique amène une diminution progressive de concentration moléculaire du liquide coelomique.

6. Les échanges osmotiques se font surtout au niveau de la cuticule.

7. Celle-ci est perméable à l'eau dans les deux sens et nous croyons que son principal rôle est de participer à la régulation osmotique.

8. Les courbes obtenues sont des courbes d'endosmose caractéristiques analogues à celles que d'autres auteurs ont obtenues sur le muscle par exemple.

9. *In vitro* tout au moins, les échanges sont conditionnés surtout par des différences de concentration moléculaire.

10. Les différences présentées par plusieurs animaux placés dans une même solution, s'expliquent par la tension élastique différente des membranes, et par la quantité relative de liquide différente contenue dans chaque animal.

Ce travail a été fait au Laboratoire de Parasitologie de l'Université de Genève. Nous adressons tous nos remerciements à Monsieur le Prof. André pour ses conseils, ainsi qu'à MM. Brunner et Landry, vétérinaires, grâce à qui nous avons toujours pu obtenir du matériel frais.

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(*MS. received for publication*, 26. II. 1925.—Ed.)

CARYOPHYLLAEUS INDICUS N. SP. (~~TREMATODA~~ Cestoda) FROM THE CAT-FISH (*CLARIAS BATRACHUS* BL.).

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(With 3 Text-figures.)

The worm described in the present paper was obtained from the stomach of the common cat-fish, *Clarias batrachus* Bl. from Nagpur, C.P., India. Only 5 out of the 22 individuals examined harboured this parasite and as many as eight were obtained from a single individual. With the exception of two specimens, they were preserved in glycerol and were not subsequently used. The remaining two specimens were flattened out between glass slides and fixed in Mann's fluid.

The body is elongated and flat with no trace of internal or external segmentation and measures approximately 25 mm. in length with a maximum width, at the junction of the anterior and middle thirds of the body, of 4·4 mm. In the middle of the body the width is 3·9 mm. The head is stumpy and bluntly rounded, markedly narrower than the body, measuring about 3 mm. in length and 1·23 mm. in width. There is a small neck-like constriction. The body tapers posteriorly, the posterior extremity being narrow and rounded.

The genital apertures are situated at the beginning of the last seventh of the body-length. The aperture of the cirrus-sac is separate from the vagino-uterine aperture, the space between the two being approximately 270 μ.

The uterus (Fig. 2, *u.*) and vagina (*v.*) open by a broad common aperture (*v.u.a.*) about 250 μ wide situated below the cirrus-pore but distinctly separate from it. The vagina is a narrow tube running in the median longitudinal line. Anteriorly, it dilates to form a cup into which the uterus opens. Posterior to the ovary, it is joined by a small duct (*vit.d.*) from the transverse vitelline sac (*vit.s.*), the joining of the two being marked by a slight dilatation.

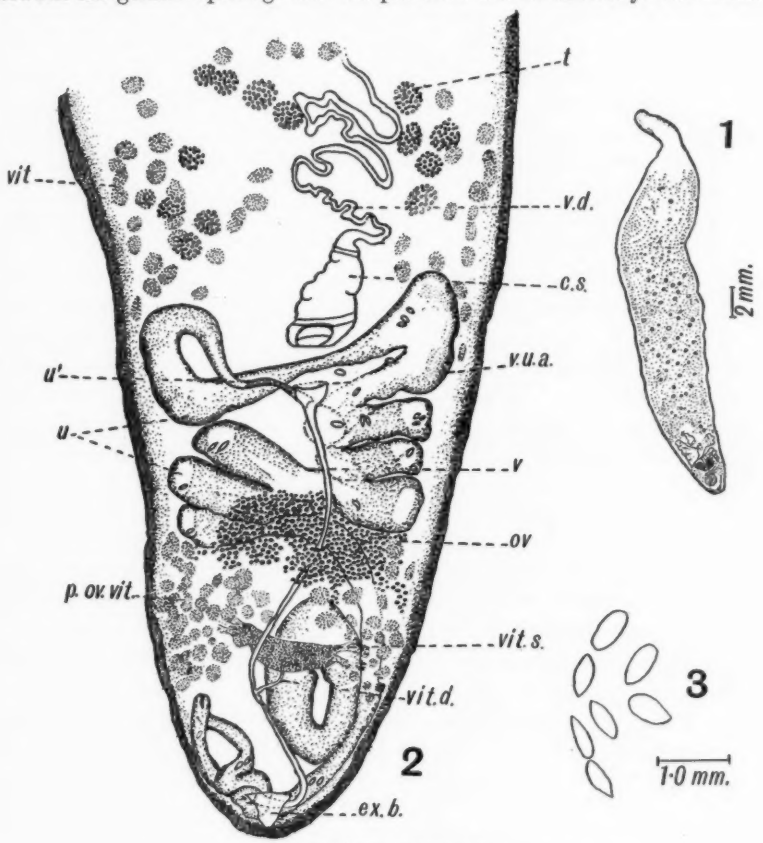
The uterus (*u.*) begins as a simple thin-walled tube posterior to the transverse vitelline sac. It passes to the posterior end of the body and then forward, forming several conspicuous thick-walled loops on either side of the body, posterior to the genital apertures, and one loop at either side at the level of the space between the apertures. The last $\frac{1}{2}$ mm. of its length (*u.'*), before joining the vagina, becomes distinctly narrowed and is ciliated.

CORRIGENDA.

Parasitology, Vol. XVII, No. 2 (v. 1925).

P. 232 and on cover in title of paper by M. A. Moghe, *for* "Trematoda" *read* "Cestoda."
P. 234, in page-heading, *for* "Trematode" *read* "Cestode."
P. 233, *after* "Fig. 2. Posterior Extremity" (in legend), *add* "× 115."

The ovary (Fig. 2, *ov.*) is irregular in shape and without sharp outlines; it spreads across the median portion of the body a little less than half-way between the genital openings and the posterior end of the body. Its median



Caryophyllaeus indicus n. sp.
Fig. 1. Entire Worm. Fig. 2. Posterior Extremity.
Fig. 3. Eggs in Balsam.

ABBREVIATIONS USED.

Lettering *c.s.* = cirrus-sac. *ex.b.* = excretory bladder. *ov.* = ovary. *p.ov.vit.* = post-ovarian vitellaria. *t.* = testes. *u.* = uterus. *u.'* = ciliated terminal portion of uterus. *v.* = vagina. *v.d.* = vas deferens. *vit.* = vitellaria. *vit.d.* = duct from the transverse vitelline duct. *vit.s.* = transverse enlargement of vitelline duct. *v.u.a.* = vagino-uterine aperture.

portion is not markedly narrower than the lateral portions as is usual in other species of *Caryophyllaeus*.

The vitellaria (Fig. 2, *vit.*) occupy the greater part of the body anterior to the genital openings and posterior to the head; they are most abundant in the lateral parts of the body (Fig. 1).

The eggs (Fig. 3) lie in the convolutions of the uterus and measure (in balsam) approximately $80\mu \times 40\mu$.

The testes (Fig. 2, *t.*) are scattered among the vitellaria, beginning a short distance behind the most anterior vitellaria and extend posteriorly to about the level of the junction of the cirrus-sac and vas deferens; they, therefore, occupy nearly two-thirds the body-length.

The cirrus-sac (Fig. 2, *c.s.*) is a large conical bell-shaped sac, the base of the cone towards the elliptical opening being posterior. The long axis of the cirrus-sac corresponds to the long axis of the body. The vas deferens (*v.d.*) is a loosely convoluted tube passing forward in the median part of the body.

Lühe (1910) has divided the family Caryophyllaeidae into two genera, *Archigetes* and *Caryophyllaeus*, and Woodland (1923) has added to it a new genus, *Wenyonia*. The genus *Monobothrium* Diesing (which included *Ligula tuba* Wagener and *C. punctatus* Molin) and also the genus *Diporus* (including a single species *C. trisignatus* Molin) were based only on the differences in the character of the head. The other characters of both these genera, *Diporus* and *Monobothrium*, are the same as those of *Caryophyllaeus*. *Monobothrium tuba* Wagener was subsequently included in the genus *Caryophyllaeus* both by Wagener himself (1854) and Monticelli (1893). Finally, the genus *Glaridacris* Cooper (including a single species *G. catastomi* Cooper 1920) resembles the other species of *Caryophyllaeus* in all characters except the shape of the head (with six loculi and a central papilla) and in this character it resembles *Monobothrium hexacotyle* Linton 1891. Since the shape of the head is very variable in different species, and even in single individuals, according to the state of contraction or expansion, Woodland concludes that all these three genera should be merged in *Caryophyllaeus*, with which opinion I entirely agree.

The genus *Archigetes* is separated from the other two genera of Caryophyllaeidae by the possession of a "caudal appendage." The position of the genital apertures can be used as a convenient character for distinguishing between *Caryophyllaeus* and *Wenyonia*: in the former, they are situated in the posterior half of the body, and in the latter, in the anterior half. In *Wenyonia*, also, the testicular region is shorter than the area occupied by the convolutions of the uterus.

The three species of *Wenyonia* described by Woodland (1923) were all obtained from Siluroid fishes and though the worm described in the present paper was obtained from a fish belonging to the same family, it clearly belongs to the genus *Caryophyllaeus*, having neither of the characters on which Woodland founded his new genus.

None of the other described species of *Caryophyllaeus* have been recorded from Siluroid fishes and no species have hitherto been described from India.

The previously described species of *Caryophyllaeus* fall into two well-defined groups on the basis of the presence or absence of a common male and female genital opening. Only two of these species, in common with the one here

described, so far as I can find from the descriptions available to me[1], have separate genital openings, namely *C. tuba* Wagener and *C. filiformis* Woodland. The species described in the present paper is readily distinguishable from *C. filiformis* by the presence of post-ovarian vitellaria, the shape of the body, median position of the ootype and the shape and extent of the ovary. From *C. tuba* it is distinguishable by the shape of the body, shape of the ovary, the position of the genital openings and the longitudinal position of the cirrus-sac. I consider it, therefore, to be a new species for which I propose the name *Caryophyllaeus indicus*, with the following specific characterisation:

> Body broad and flat, approximately 25 mm. in length, with a maximum width of 4·4 mm.; head narrow, about 1·23 mm. in width, stumpy and bluntly rounded; male and female genital apertures separate; uterine and vaginal apertures common; post-ovarian vitellaria present; genital apertures situated at the beginning of the last seventh of the body-length; eggs (in balsam) measure approximately $80\mu \times 40\mu$. Parasite in the intestine of the Siluroid fish, *Clarias batrachus* Bl., Nagpur, India.

In conclusion, I desire to express my indebtedness to Dr Asa C. Chandler for very valuable guidance at every stage in the preparation of this paper.

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[1] I have omitted to consider the characters of *C. truncatus* Molin and *C. trisignatus* Molin because the only descriptions available to me were those given by Carus (1885, p. 121) which are restricted only to the shape of the anterior and posterior ends of the body. The shape of the head (extremely variable) cannot be used as a character for distinguishing the species. Both these worms are, however, much smaller (*C. truncatus* 4–10 mm. and *C. trisignatus* 2–7 mm. in length) than the present species. Another species, not considered for the same reason, is *Caryophyllaeus* (*Glaridacris*) *catastomi* Cooper 1920; but this species also differs from my new species in being narrower and by possessing loculi on the head and also in the smaller size of the eggs.

(*MS. received for publication* 9. iii. 1925.—Ed.)

ERRATA.

Parasitology, Vol. XIV. (1922), p. 418. The statement that Cobbold's likeness (Portrait-plate XX) was taken in 1884 was made on what I regarded as the best authority. My friend, Dr Albert Hassall, of the Bureau of Animal Industry, U.S. Department of Agriculture, Washington, D.C., informs me, however, that the late Dr Cobbold gave him a corresponding photograph in the year 1879. Therefore the date "1884" should be replaced by "about 1879."

Parasitology, Vol. XVI. (1924), p. 222. In the translation of Robert Koch's letter, owing to the somewhat obscure original writing, I read "Selbstverständlich" for "Selbstveröffentlicht" in the last sentence, therefore substitute for "Naturally I have not referred to this..." the words "I have not myself published anything about it...."

G. H. F. NUTTALL.